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PUBLISHED QUARTERLY BY THE SOCIETY
COLUMBUS, OHIO

Entered as second class matter April 11, 1908, at the Post Office at Columbus, Ohio, under the Act of Congress of March 3, 1879.

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ANNALS

OF

The Entomological Society of America

Volume VII SEPTEMBER, 1914 Number 3

SPIDERS COLLECTED BY MR. C. WILLIAM BEEBE IN BURMA AND BORNEO.

With Plate XXVI.

ALEXANDER PETRUNKEVITCH, PH. D.

Family Theraphosidæ.
Haplopelma Doriæ (Thorell). One female from Kuching, Borneo.

Family Drassidæ.
Drassodes Drydeni n. sp. One male from Pongatong, Burma.
Drassodes ignobilis n. sp. One female from Tabu Pum, Burma.

Family Pholcidæ.
Pholcus phalangioides Fussl. One female from Wahsaung, Burma.

Family Theridiidæ.
Theridion sarapus Thorell. Two females from Pongatong, Burma.
Dipoena tristis n. sp. One female from Tabu Pum, Burma.
Enoplognatha marmorata L. One immature female from Tabu Pum, Burma.

Family Linyphiidæ.
Erigone longipalpus F. Two males and two females from Tabu Pum, Burma.
Linyphia sp? One immature female from Tabu Pum, Burma.

Family Clubionidæ.
Clubiona tabupumensis n. sp. One female from Tabu Pum, Burma.
Clubiona sp? One young from Tabu Pum, Burma.
Clubiona sp? Two young from Wahsaung, Burma.
Palystes sp? One young from Wahsaung, Burma.

Family Argiopidæ.

Nephila maculata F. One female from Wahsaung, Burma.
Nephila clavata L. Koch. Two females from Tabu Pum, Burma.
Leucauge tesselata (Thorell). One female from Pongatong, Burma.
Gasteracantha arcuata F. One female from Kuching, Borneo.
Gasteracantha frontata Bl. Two females from Kuching, Borneo.
Theridiosoma sp? One young from Tabu Pum, Burma.
Araneus microtuberculatus n. sp. One female from Tabu Pum, Burma.
Araneus Beebei n. sp. One female from Wahsaung, Burma.

Family Thomisidæ.

Philodromus tabupumensis n. sp. One female from Tabu Pum, Burma.
Bomis sp? One young without abdomen, from Wahsaung, Burma.
Porrhopis sp? One young from Wahsaung, Burma.

Family Lycosidæ.

Lycosa stictopyga Thorell. One female from Tabu Pum, Burma.
Lycosa (Pirata) sp? One immature female from Tabu Pum, Burma.
Lycosa sp? One young from Tabu Pum, Burma.

Family Oxyopidæ.

Oxyopes sp? One young from Wahsaung, Burma.
Oxyopes sp? Two young from Wahsaung, Burma.

Family Salticidæ.

Evophris sp? One young from Wahsaung, Burma.
Evophris albopatella n. sp. One male from Wahsaung, Burma.
Cobanus Beebei n. sp. One male from Central Borneo.
Ballus tabupumensis n. sp. One female from Tabu Pum, Burma.
Attulus sp? One young from Wahsaung, Burma.
Thiania sp? One young from Wahsaung, Burma.

Description of new species.

Drassodes Drydeni* n. sp. (Plate XXVI, figs. 1 and 2).

Total length 7.4 mm. Cephalothorax and all appendages brown, abdomen grey. Sternum oval, pointed behind, broadly truncated in front. Lip much longer than wide. Laminæ maxillares strongly impressed. All femora slightly thickened. Cephalothorax much narrower in front than in middle. Anterior row of eyes recurved, posterior procurved. AME half their diameter apart, subcontiguous with ASE. Eyes of second row aequidistant. ASE separated from PSE by less than half their diameter. AME slightly larger than ASE. Anterior row viewed from in front curved downward. Clypeus as high as AME. First tarsus and metatarsus with a heavy scopula. Second tarsus with a scopula only in its distal half. Second metatarsus without scopula.

* In honor of Mr. John Dryden Kuser.

Heavy spines on all legs. Femur of pedipalp with a short blunt subterminal apophysis on the inside. (Plate XXVI, fig. 2). Copulatory apparatus with an extremely long and thin embolus (Plate XXVI, fig. 1).

One male from Pongatong, Burma.

Drassodes ignobilis n. sp. (Plate XXVI, fig. 3).

Total length 5.9 mm. Cephalothorax and all appendages brown, abdomen dark grey. All femora slightly thickened. Tarsi without scopulæ. Sternum oval, broadly truncated in front, pointed behind. Lip longer than wide. Laminæ maxillares strongly impressed. Fourth legs with spines. All femora with two long, upright spines in median dorsal line. No spines on other joints of first, second and third leg. Anterior row of eyes recurved, posterior row procurved. PME about their diameter apart. PSE about half diameter from PME. Eyes of anterior row equal in size, contiguous. Anterior row viewed from in front curved downward. Side eyes separated by about half their diameter. Clypeus as high as AME. Epigynum as figured, much higher than wide.

One female from Tabu Pum, Burma.

Dipoena tristis n. sp. (Plate XXVI, fig. 4).

Total length 4.8 mm. Cephalothorax and legs reddish brown, Abdomen dark greyish brown with a narrow dark median line and two pairs of transverse whitish bands. No spines on legs. Sternum triangular. Anterior coxæ widely apart. Lip wider than long. Anterior row of eyes strongly recurved, posterior row straight, longer than anterior. Eyes of posterior row aequidistant and equal in size. Side eyes contiguous, equal. AME smaller than the other eyes. Eyes of anterior row aequidistant. Clypeus as high as quadrangle. Epigynum as figured.

One female from Tabu Pum, Burma.

Clubiona tabupumensis n. sp. (Plate XXVI, fig. 5).

Total length 7.8 mm. Cephalothorax and all appendages yellowish brown, abdomen grey. Anterior row of eyes much shorter than posterior row, slightly recurved. Posterior row almost straight. Quadrangle wider than long, much narrower in front than behind. Eyes of anterior row aequidistant, separated from each other by somewhat less than their diameter. PME somewhat farther from each other than from the PSE. Distance between the PME equal to about 2½ their diameter. Clypeus not more than half the diameter of the AME. Sternum a long oval, pointed behind, truncated in front. Lip much longer than wide. First and second tarsi and metatarsi with a thick scopula. Similar scopula on distal half of third and fourth tarsi. First tibia with 2-2 long spines below, first metatarsi with 2 long spines at base below. Third and fourth tibiæ with a row of 3 spines in median line below, 2 laterals inside

and 2 laterals outside. Third and fourth metatarsi with spines below, above and laterals. Epigynum very small, considerably in advance of genital slit.

One female from Tabu Pum, Burma.

Araneus microtuberculatus n. sp. (Plate XXVI, figs. 6, 7, 8).

Total length 2.8 mm. Cephalothorax high, without groove or stria. Abdomen with two tubercles or shoulders in front and two prominent tubercles behind. (Plate XXVI, figs. 7, 8). Integuments soft. Side eyes subcontiguous, on black tubercles. ASE much smaller than PSE. Both rows of eyes recurved. Quadrangle wider behind than in front, wider than long. PME much larger than AME. Clypeus lower than quadrangle, about twice the diameter of the AME. Sternum triangular, broadly truncated in front. It is also truncated behind, between the hind coxæ which in consequence are separate. Lip triangular, very wide. Chelæ smooth, inferior margin with 3 teeth, superior with 4 teeth. Pedipalpi with a claw. One dorsal spine at end of all patellas. One inside lateral spine on first femur and tibia. Upper claws almost cordate, with four teeth each. Third claw smooth. Epigynum as figured. (Plate XXVI, fig. 6). Color in alcohol: cephalothorax brown with a median white spot. Chelæ brown, legs brown, femora lighter than other joints. Sternum dark brown, lip and laminæ with tips of lighter color. Abdomen above mottled with white and brown, tubercles dark. Sides whitish with three dark lines. Below almost black. Spinnerets brown.

One female from Tabu Pum, Burma.

Araneus Beebei n. sp. (Plate XXVI, figs. 9, 10).

Total length 2.5 mm. Cephalothorax with a somewhat recurved groove. Clypeus not half the diameter of the AME. Quadrangle much wider in front than behind. Anterior row strongly recurved, posterior row slightly recurved. AME are the largest eyes. Chelæ distinctly longer than thick. Inferior margin with 3 teeth, superior margin with 4 teeth. Abdomen oval, considerably overlapping cephalothorax. Sternum triangular, widely truncated in front, produced behind between the fourth coxæ which are separate. Pedipalpi with a claw. Legs with many spines. Two rows of long bristles below all femora, especially on those of the first and second pair. Epigynum as figured, brown and relatively very large. (Plate XXVI, fig. 9). Color in alcohol : cephalothorax greyish brown, legs yellow, sternum, lip, laminæ, pedipalpi and chelæ also yellow. Abdomen (Plate XXVI, fig. 10) above grey with white iridescent spots, a transverse anterior black band and a large median more or less triangular black spot pointed backwards. Below grey with iridescent white spots.

One female from Wahsaung, Burma.

Philodromus tabupumensis n. sp. (Plate XXVI, fig. 11).

Total length 4.8 mm. Cephalothorax 1.8 mm. long, 2.0 mm. wide. Legs 2134. Anterior row of eyes shorter than the posterior row and recurved. Posterior row very slightly recurved, almost straight. Anterior eyes about equal in size, AME farther from each other then from the ASE. PME smaller than the PSE, the distance between the PME much larger than between the PME and the PSE. Quadrangle narrower in front than behind, about as wide as long. Clypeus 1½ diameters of the AME. Sternum longer than wide, emarginate between hind coxæ which are widely separate. Spines on all segments of legs and palpi, except tarsi. First femur 2.2 mm. long, second 2.6 mm. Color in alcohol: cephalothorax light brown with black marginal and three black longitudinal parallel bands. A narrow, curved black band runs in front of the eyegroup, touches the PSE on each side of the head and merges with the median longitudinal band at the posterior margin of the cephalothorax. Legs yellow, spotted above with dark brown. Abdomen above light brown with two dark brown V-shaped spots pointed forward, sides dark brown, underside altogether light yellow. Epigynum as figured.

One female from Tabu Pum, Burma.

Evophris albopatella n. sp. (Plate XXVI, figs. 12, 13).

Total length 2.7 mm. Legs 4312. Inferior margin of chelæ with one tooth, superior with a row of eight teeth. Of these only the proximal two are large, while the others are exceedingly small. (Plate XXVI, fig. 12). Cephalic part shorter than thoracic. Eyegroup wider in front than behind. ASE very prominent. Eyes of second row minute, situated in middle. Iridescent white scales above AME, between side eyes on face and along the edge of the cephalothorax which is very dark brown. First, second and third femur, patella and tibia dark brown above and below. Fourth femur yellow with a dark brown spot above at distal end. Fourth patella and tibia yellow above with two lateral dark brown lines, below yellow. All other joints of all legs yellow. Palpi dark brown except patella which is covered with white iridescent scales. Sternum, lip and laminæ dark brown with yellow edges. Chelæ reddish brown. Abdomen above yellow with two parallel longitudinal dark brown bands and white iridescent scales. Below yellow with a median dark brown broad band. Tibia of pedipalp with a curved apophysis, copulatory apparatus as figured. (Plate XXVI, fig. 13).

One male from Wahsaung, Burma.

Cobanus Beebei n. sp. (Plate XXVI, figs. 14-18).

Total length without mandibles 9.0 mm. Cephalothorax 3.8 mm. long, 3.1 mm. wide. Chelæ long, with long, curved fang. Length of chelæ without fang 3.8 mm. Superior margin with two teeth of

which the subapical one considerably larger than the proximal. Inferior margin with two teeth. (Plate XXVI, fig. 14). Legs 3142. Cephalothorax high. Eyes of second row small, situated behind the middle. Measurements of legs: First leg—femur 4.6 mm., tibia+patella 5.5 mm. metatarsus+tarsus 4.8 mm.; Second leg—femur 3.3 mm., tibia+patella 3.5 mm., metatarsus+tarsus 3.6 mm.; Third leg—femur 5.2 mm., tibia+patella 5.1 mm., metatarsus+tarsus 5.8 mm.; Fourth leg—femur 3.0 mm., tibia+patella 3.7 mm., metatarsus+tarsus 4.5 mm. All legs with many heavy spines. Tibia of first leg curved, with 4-4 spines below. First metatarsi straight, with 2-2 long spines below and laterals. A heavy comb of black hair above and below first patella, a comb of shorter hair on distal half of femur and one of quite short hair on back of first tibia (Plate XXVI, fig. 15). Claws as figured (Plate XXVI, fig. 17). Sternum longer than wide, lip not reaching half of laminæ. (Plate XXVI, fig. 16). Tibia of pedipalp with a straight apophysis, copulatory apparatus as figured (Plate XXVI, fig. 18). Color in alcohol: cephalothorax red-brown, with two lateral white patches and a fringe of brown hair around the eyes. Chelæ above red-brown, below black. Fang black with red-brown tip. Pedipalpi yellow. First femur and patella very dark brown, tibia yellow with dark brown distal end, metatarsus and tarsus dark brown. Other legs brown, fourth leg lighter. Lip and laminæ dark brown, sternum reddish brown. Abdomen dark grey above and below.

One male from Central Borneo.

Ballus tabupumensis n. sp. (Plate XXVI, figs. 19, 20).

Total length 5.7 mm. Legs 1423. Cephalothorax flat and square. Eyegroup wider behind than in front. Pars cephalica longer than pars thoracica. Eyes of second row minute, situated considerably in front of middle. Posterior row somewhat shorter than width of cephalothorax. Chelæ short and heavy (Plate XXVI, fig. 20) with a humped back carrying a row of tubercles. Inferior margin with three teeth of which the middle one is the smallest. Superior margin with a row of 12 very small teeth. Sternum much longer than wide, posterior coxæ contiguous. Lip longer than broad, laminæ very long with emarginate outer edge, wider at end than at base, inclined over lip. First leg much heavier than the others. First femora dilated. First tibia with 3 - 3 heavy spines below and no laterals. First metatarsus with 2 - 2 very heavy spines below, the first pair reaching beyond the middle of the article and the second pair almost to the base of the claws, no laterals. Claws with a single tooth. Epigynum as figured (Plate XXVI, fig. 19). Color in alcohol: cephalothorax, chelæ and first leg very dark brown. Abdomen and femora of second, third and fourth pair brown. Other joints of second, third and fourth leg yellow with dark spots. Underside dark brown.

One female from Tabu Pum, Burma.

Explanation of Plate XXVI.

Drassodes Drydeni n. sp.—male.
Fig. 1. Copulatory apparatus of male.
Fig. 2. Femoral apophysis of pedipalp.

Drassodes ignobilis n. sp.—female.
Fig. 3. Epigynum.

Dipoena tristis n. sp.—female.
Fig. 4. Epigynum.

Clubiona tabupumensis n. sp.—female.
Fig. 5. Epigynum.

Araneus microtuberculatus n. sp.—female.
Fig. 6. Epigynum.
Fig. 7. Sideview of abdomen and cephalothorax.
Fig. 8. Dorsal view of abdomen.

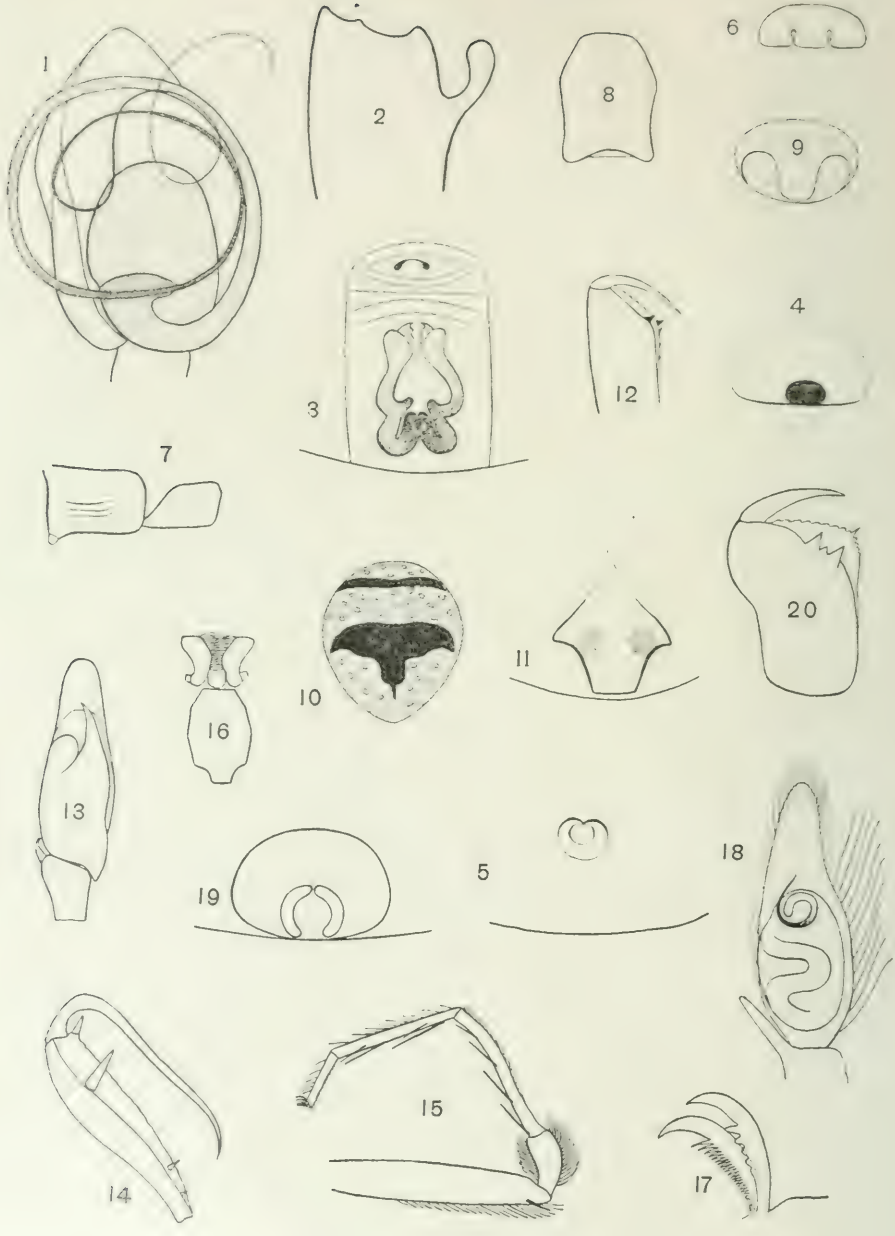
Araneus Beebei n. sp.—female.
Fig. 9. Epigynum.
Fig. 10. Dorsal view of abdomen.

Philodromus tabupumensis n. sp.—female.
Fig. 11. Epigynum.

Evophrys albopatella n. sp.—male.
Fig. 12. Chelæ.
Fig. 13. Copulatory apparatus.

Cobanus Beebei n. sp.—male.
Fig. 14. Chelæ.
Fig. 15. First leg.
Fig. 16. Sternum, lip and laminæ.
Fig. 17. Claws.
Fig. 18. Copulatory apparatus.

Ballus tabupumensis n. sp.—female.
Fig. 19. Epigynum.
Fig. 20. Chelæ.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THE RAVAGES, LIFE HISTORY, WEIGHTS OF STAGES, NATURAL ENEMIES AND METHODS OF CONTROL OF THE MELON FLY (DACUS CUCURBITAE COQ.).

HENRY H. P. SEVERIN, Ph. D. HARRY C. SEVERIN, M. A.
WILLIAM J. HARTUNG, B. S.

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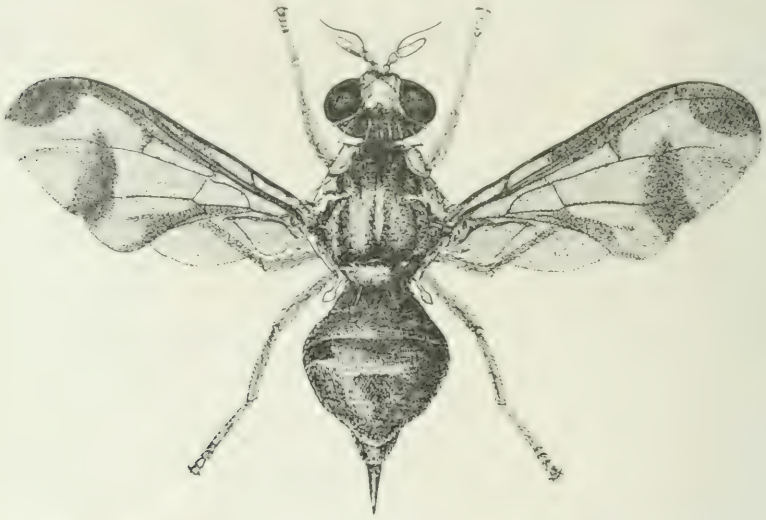
I. Introduction.

The most destructive pest of the Cucurbitaceæ in the Hawaiian Islands is commonly called the Melon Fly (Dacus cucurbitæ Coq.) or the Bitter Gourd Fruit Fly in other parts of the world. Previous to the accidental introduction of this insect into Hawaii, melons were sold at ten cents each, but today the consumer often pays from fifty cents to one dollar for a watermelon. It has been estimated that the loss in the Hawaiian Islands amounts to almost a million dollars annually, in tribute to this fly, or a little over five cents a day for a family

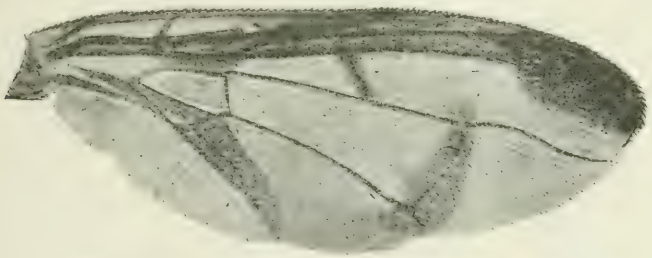


Text Fig. 1. Melon fly, Dacus cucurbitæ Coq. (After Perkins).

of four, on an estimated population of 192,000. When one stops to consider that the Hawaiian Islands are smaller than the state of Rhode Island, that the principal agricultural products are sugar, pineapples, coffee and rice, one realizes what a tremendous amount of injury this fruit fly causes to the limited vegetable crops grown in the islands. This trypetid has been allowed to play havoc unmolested for a period of sixteen years or more, so that today in many localities swarming with the pest, barely do the seeds of some cucurbits germinate, when the seedlings are "stung" by the flies; the larvæ which hatch from the eggs devour the tissue of the stems and cause decay, then the maggots penetrate into the roots and completely destroy the plants.

II. Native Home.

Some difference of opinion exists as to the native home of the melon fly. Muir (5, p. 17) "found that India was its original home" and later on, Froggatt's (5, p. 17) investigations showed that the melon fly was widely distributed over India and also Ceylon. Perkins (10, p. 36) believes "its true home is no doubt in China or Japan." In a map showing the fruit fly regions with steamship connections to California, Compere (2, p. 728) records the danger of introducing the pest into that state from the following sea ports: Hawaiian Islands, Timor, Manila, Nagasaki, Hongkong, India and Singapore. Compere claims that this pest is rarely found in the Philippine Islands and he informed the writers that the melon fly was originally native of these islands. It was imported from one of the above mentioned countries into the Hawaiian Islands about the year 1897.



Text Fig. 2. Wing of melon fly. (After Froggatt).

III. Description of Melon Fly.

The melon fly is wasp-like in its general shape and behavior and resembles a hornet (Polistes) somewhat in color but is less than half as large. The head is yellow in color; the thorax is reddish yellow marked with a number of light yellow areas and the abdomen is yellow on the first two segments and reddish-yellow on the others. At the base of the second, abdominal segment is a transverse black line, which unites with a black, dorsal, median line on the next three segments. A lateral, brown spot is usually present on the fourth and fifth segments. The transparent wings are marked with brown bands. A brown band extends along the front margin of each wing and ends in a large spot at the apex; another brown band extends along a fold of the wing near the body; between the distal ends of these bands is a transverse marking (Text fig. 2). The legs are light yellow in color.

Compere (2, p. 710) recognized the melon fly as a new species in Hawaii and sent specimens to Coquillet (3, pp. 129-130) whose original description follows:

"*Dacus cucurbitæ*.—Head light yellow; the occiput, except the sides and upper margin, reddish-yellow, an ocellar black dot, front marked with a brown spot in front of its centre, and with three pairs of orbital brown dots, a black spot on each side of the face near the middle, and a brown spot on the middle of each cheek; antennæ, palpi, and proboscis yellow, the latter mottled with brown; thorax, reddish-yellow, the humeri, a median vitta on the posterior half of the mesonotum, another on each side, above the insertion of the wings, uniting with an irregular band which extends upon the pleura to the upper part of the sternopleura, also a large spot on each side of the metanotum, encroaching upon the hypopleura, light yellow; scutellum, except its extreme base, light yellow, bearing two bristles; abdomen light yellow on first two segments, reddish-yellow on the others, the extreme base, a fascia at the bases of the second and third segments, usually a lateral spot on the fourth and fifth, also a dorsal vitta on the last three segments, blackish or brownish; first segment of the ovipositor of the female slightly longer than the fifth segment of the abdomen. Wings hyaline, the apex of the subcostal cell, from a short distance in front of the apex of the auxiliary vein, the marginal and submarginal cells, the median third of the first basal cell, and a large spot in upper outer corner of the first posterior cell, brown, this colour encroaching on the third posterior cell and bordering the sixth vein almost to its apex; posterior cross vein bordered with brown, this colour extending to the hind margin of the wing; upper end of the small cross vein is also bordered with brown. Halteres light yellow. Legs light yellow, the broad apices of the femora and the last four joints of the tarsi reddish-yellow; hind tibiæ reddish-yellow or dark brown. Length, 6 to 8 mm. Type No. 4,207 in the United States National Museum."

IV. Field Observations in a Pumpkin Patch.

Casual observations on the injuries caused by the melon fly have been put on record but no intensive study of its destructive work has as yet been published. In our work careful examinations were made of different parts of pumpkin plants to ascertain the following points: (1), where the pest deposits

its eggs under natural conditions; (2), the external indication of egg deposition and (3), the injury caused by the larvæ. Observations were also noted on other host plants injured by this fruit fly, but these were not so extensive as those made on pumpkin plants.

1. *Oviposition in stems of pumpkin vines.*—The melon fly often deposits its eggs in the stems of cucurbit seedlings. In pumpkin vines the eggs are often laid within the tender stems near the growing ends (plate XXVII, fig. 3), but the pest is not able to puncture the older and tougher stems with its needle-like ovipositor. A gummy substance exudes from the wound and hardens in the form of a small, resinous lump on the stems (plate XXVII, figs. 1 and 2).

2. *Oviposition in petioles of leaves.*—Occasionally the melon fly deposits its eggs within the petioles of the leaves. The external indication of oviposition, as in the case of the stems, is shown by the resinous material which accumulates at the region where the petiole was punctured by the ovipositor.

3. *Oviposition in pumpkin flowers.*—Eggs were found on the outer and inner surfaces of the corolla and its lobes (plate XXVII, figs. 4 and 7). When the melon fly oviposits on the inner surface of a corolla, it punctures the closed flower, glueing the eggs either at one end in a mass or scattering them loosely on the inner surface of the corolla and its lobes. At that region where the flower has been punctured it becomes discolored (plate XXIX, figs. 20 and 21).

Dacus often oviposits within a receptacle formed by its ovipositor in the anthers or column of the stamens of the staminate pumpkin flowers. More often, however, eggs are deposited in the tissue of the cup-shaped disc formed by the union of the calyx and corolla, or the eggs are simply dropped loosely into this cup-shaped disc. Occasionally, the eggs may also be found within the peduncle of the staminate flowers.

The pest also deposits its eggs in the stigmas and styles of the pistillate flowers. The trypetid does not enter the male or female pumpkin flowers to lay its eggs, but punctures the corolla from the outside with its ovipositor. Wherever the ovary of the pistillate flower has been "stung" by the female fly, a resinous material covers the wound (plate XXIX, fig. 18). Within the ovary, the ovipositor forms a small receptacle in which the eggs are laid (plate XXVII, figs. 5 and 8). Eggs

are often deposited in the constriction between the perianth and ovary, as is shown by the resinous substance found frequently in this region (plate XXIX, fig. 19).

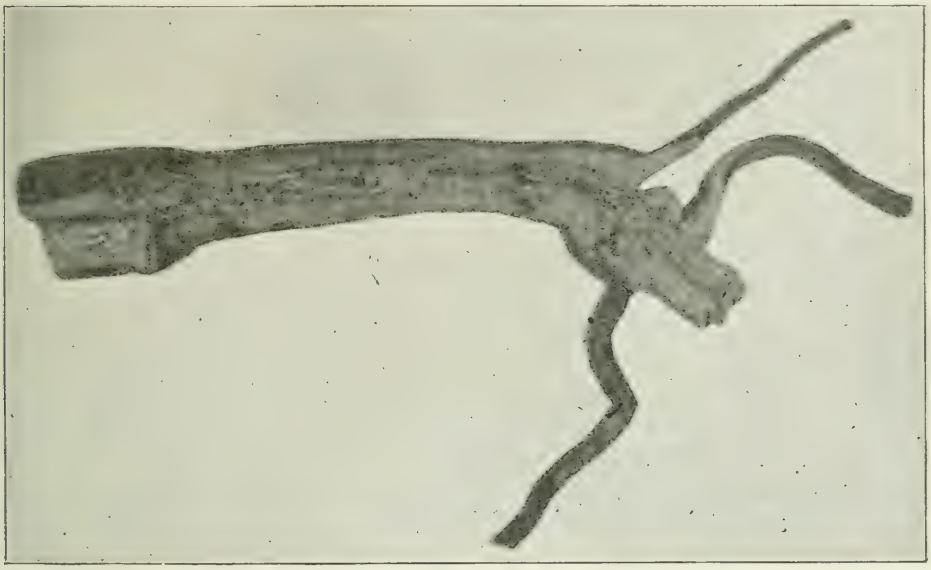
Green staminate and pistillate buds are often "stung" by the fly, the eggs being laid in the various parts of the unopened flowers (plate XXVII, fig. 6), as has just been described for the mature flowers.

4. *Oviposition in pumpkins*—The trypetid deposits its eggs in small, green pumpkins, but the larger, uninjured pumpkins are immune from the attacks of the pest, because the fly is unable to pierce a hard rind with its ovipositor. If, however, the rind of a large pumpkin has been injured, the fruit fly will lay its eggs within the wound. The insect will oviposit in an exceedingly small hole extending through the resinous substance of a healed wound, such as is often due to a previous infestation by the pest (plate XXVIII, fig. 10). On a pumpkin in the field, eighteen melon flies were counted with their ovipositor inserted within a crack extending through the resinous exudation of such a wound and new arrivals were coming continuously to oviposit in the same place. At the end of that day the resinous material was removed, and hundreds and hundreds of eggs were found closely packed in the pulp beneath the crack.

After the melon fly "stings" the unripe pumpkin and squash, the tissue surrounding the receptacle in which the eggs are laid is killed, probably by a secretion which the fly pours over the eggs. In the further development of these cucurbits a depression results (plate XXVIII, figs. 9, 11 and 12) wherever oviposition has occurred. Small pumpkins which have been "stung" repeatedly, may assume all sorts of abnormal shapes in their further growth (plate XXVIII, fig. 12).

5. *Injury to stems.*—The recently hatched larvæ devour the tissue of the tender stems of young cucurbits and cause decay, then they penetrate the roots and destroy the plants entirely. Several acres of watermelons under observation were replanted a number of times and, without exception, every plant was destroyed in this way. The maggots often destroy the terminal shoots of old pumpkin vines by penetrating from one internode to another and feeding on the tissue of the tender stems. A yellowish substance, probably the excrement of the pest, stains the undevoured fibrous tissue of the stems. No maggots were found in the old stems or roots.

The old stems of the pumpkin vines are often infested with the larva of a Cerambycid (Apomecyna pertigera) which is able to penetrate through the hard nodes. More often, however, this beetle larva was found in the roots of the pumkin plant (Text fig. 3.)



Text Fig. 3. Root of a pumpkin vine split open lengthwise showing the larva of a Cerambycid (Apomecyna pertigera) which feeds on the tissue of the roots and occasionally of the stems.

6. *Injury to petioles.*—Melon fly larvæ, which had recently hatched, were found within the petioles of leaves, but nearly, full-grown maggots were never observed within this part of the plant. In order to ascertain whether the pest could complete its larval period within a petiole, ten maggots of different sizes were placed within a half dozen leaf-stalks. All of the larvæ obtained sufficient nourishment from the wall of the petioles to complete their development. While most of the maggots bored out of the petioles to pupate, others pupated within the leaf-stalks close to the node of the stem.

7. *Injury to flowers.*—The larvæ that hatch from the eggs deposited in the anthers, first feed upon and destroy these structures (plate XXIX, fig. 28); then they may eat out the

column of the stamens (plate XXIX, fig. 29); next the pests may work their way down into, and entirely destroy the cup-shaped disc beneath the column and finally they may penetrate into the long peduncle. The flower often drops from its stalk (plate XXIX fig. 30) on account of a decay which follows an infestation. The wall of the peduele is now eaten until only a thin, papery envelope remains, which encloses a yellowish substance similar to that observed in the infested stems. No evidence was found that the larvæ pass through the node which shuts off the hollow peduncle from the stem, but at this node puparia were occasionally found.

In the pistillate flowers the larvæ devour the stigmas and styles, leaving a decayed mass to which the corolla clings. The maggots then descend into the ovary and often the withered corolla becomes detached (plate XXIX, fig. 25) and drops to the ground, leaving a black, flower scar (plate XXIX, fig. 22). As the ovary is devoured, decay sets in, the pulp becomes spongy (plate XXIX, figs. 23 and 24) and the channels are filled with wriggling maggots. After the larvæ bore out, the ovary turns black and either detaches from the pumpkin vine (plate XXIX, fig. 27) and drops to the ground, or remains adhering to the vine as a dried, shriveled mass (plate XXIX, fig. 26).

8. *Injury to pumpkins.*—A green pumpkin which is infested with a small number of melon fly larvæ may continue to grow after the maggots have bored out, but when attcked by a large number of the pest, the pumpkin turns black and decays. After the larvæ have bored out of a green pumpkin, the wound becomes covered by a gummy substance (plate XXVIII, fig. 10). During the further development of this cucurbit, the resinous material often cracks and a second oviposition may occur in the crevices. If a ripe pumpkin is reinfested with a large number of maggots a rapid decay changes the pulp into a semi-liquid mass possessing a most sickening rancid odor. The rind may now collapse (plate XXVIII, fig. 15), and the thick, liquid contents then oozes out. After the maggots bore out, only the rind containing the seeds remains. A glance at plate XXVIII, figures 13 and 14, shows the remains of two pumpkins which were turned over to show the side that had been resting on the ground. In such cases the seeds drop to the ground and often germinate. When a ripe pumpkin is reinfested with a small number of larvæ the rind does not collapse (plate XXVIII, fig. 16) and the seeds within the semi-liquid pulp may then decay.

9. *Injury to string beans.*—An examination was also made of the injury which the melon fly larvæ cause to the seeds and pods of green-podded string beans. It was found that the maggots feed upon the seeds and also the fleshy part of the pods (plate XXX, figs. 31 and 32). After these portions have been consumed the inner surfaces of the pods turn black (plate XXX, fig. 33).

Dead Dacus larvæ were found within the seeds and pods of string beans. Sometimes the dried bodies of the maggots were found protruding from the pods (plate XXX, fig. 39); these evidently died in the process of boring out of the host. Pupation, which normally occurs in the ground, often takes place within the dried pods (plate XXX, figs. 36 and 37).

V. Food Plants.

In the Hawaiian Islands the melon fly has been bred from the following food plants:

VEGETABLES.	FRUITS.
Cucumber	Mango. Bred by Terry (11, p. 32).
Egg Plant	?Orange. Bred by Ehrhorn (4, p. 337).
Kohlrabi	Papaya.
Muskmelon.	
Pumpkin.	
Squash.	
String bean.	
Tomato.	
Watermelon.	
Wild cucurbit (Sycos sp.). Bred by Van Dine. (11, p. 32).	

In India, Froggatt (5, p. 18) bred Dacus cucurbitæ from melons, bitter gourds and egg plants.

10. *Number of melon flies bred from the food plants.*—To determine whether the pest could obtain sufficient food material from the corolla of pumpkin flowers to complete the larval development, the corolla was removed from six staminate flowers in the field and each corolla was then placed in a breeding jar together with recently, hatched, melon fly maggots. The larvæ during their development obtained no other food than that furnished by a single corolla. One male and one female melon fly succeeded in completing their life history on this food supply.

An experiment was now performed to determine the number of melon flies which could be bred from an entire staminate flower including its long peduncle. A dozen, infested, stam-

inate flowers were cut from pumpkin vines in the field and placed in twelve breeding jars. The following figures indicate the number of adults which were reared from each flower: 10, 14, 19, 23, 24, 25, 31, 32, 33, 37, 63 and 64; a total of 375 or an average of 31 flies for each flower.

A similar experiment was performed with a half dozen pumpkins. The cucurbits were of different sizes and were taken from the field and placed in separate breeding jars. The following figures show the size of the pumpkins and the number of adults reared from each.

From a pumpkin 2½ inches long,	277 melon flies were bred.
From a pumpkin 3 inches long,	183 melon flies were bred.
From a pumpkin 3½ inches long,	378 melon flies were bred.
From a pumpkin 3½ inches long,	464 melon flies were bred.
From a pumpkin 4 inches long,	637 melon flies were bred.
From a pumpkin 4¾ inches long,	283 melon flies were bred.
	2222 total.

From twelve, infested, green-podded string beans gathered in the field, the following number of melon flies were reared: 4, 7, 11, 11, 12, 14, 15, 15, 16, 16, 18 and 26; a total of 165 or an average of 13 flies for each pod.

VI. Life History.

Although the melon fly has been very destructive during the past sixteen years in Hawaii, the duration of the different stages of its life history have never been determined. Clark (1, p. 6) makes the following statements on the life history of this pest. The fly "stings" not only the fruit with its ovipositor, but also the young and tender growth of the vines, depositing a number of eggs, which soon hatch into small, white maggots that feed on the tissues of the fruit causing it to decay. After the maggot has attained its growth, it descends into the soil where it develops into a small chrysalis of a light, yellowish brown color, and in about ten or twelve days comes out a perfect insect, ready to repeat its mission of destruction. I do not know how many generations it will produce in a year, but in the warmer and drier districts I believe it will breed the year through, except possibly a while during the winter months, and then its development is only retarded by the cooler weather, which prevents the chrysalis maturing so rapidly."

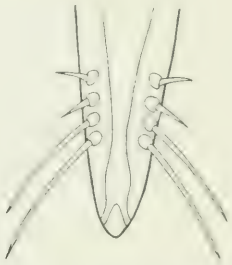
Van Dine (11, pp. 32-34) gives the following contribution on the life history of the melon fly: The life history covers a period of about three weeks. The number of eggs which the female deposits varies from 5 or 6 to as many as 15. After hatching from the egg, the larvæ burrow into the tissue of the melon and feed on the interior. When fully developed the larvæ leave the infested melon or vine and enter the soil directly beneath, where at a distance of an inch or so from the surface they pupate.

Marsh (9, p. 156) writes, "In the insectary an effort was made to work out the life history of this fly, but little progress was made owing to the fact that the cages in which the specimens were confined were too small."

11. *Methods of inducing oviposition.*—Various methods were adopted to induce melon flies to lay their eggs in different food plants placed in a pumpkin patch swarming with the pest. One method followed was to cut a non-infested, ripe pumpkin in half and the trypetids which were probably attracted by the odor of the pulp, would visit the cut surfaces and deposit their eggs. Even the removal of a small piece of the rind from a pumpkin or squash would be sufficient to attract and induce the insects to oviposit. Another method used was to make a semicircular cut through the peel and pulp near the surface of cucumbers, egg plants and tomatoes and the loose flap was then pinned back like a lid. After the females had deposited their eggs in the pulp, the lid-like peel was pinned into its normal position again, thus covering the eggs.

In one experiment about a square inch of the rind of a pumpkin was removed and in a short time melon flies began to visit the injured vegetable. The flies wandered about upon the rind until they found the exposed pulp, when they began to feed upon the exuding juices. At times as many as twenty-five specimens were clustered together in this small area. So closely crowded were the insects that their wings, which are usually held at almost right angles to the long axis of the body, overlapped. More and more individuals were attracted to the cut area until the newcomers were actually forced to walk over the bodies of the earlier arrivals, some of which were now laying eggs without apparently being disturbed, for the ovipositor was not withdrawn.

12. *Tactile bristles of the ovipositor.*—The melon fly often seeks a suitable place wherein to oviposit by walking about on the cucurbit with the tactile bristles at the end of the ovipositor (Text fig. 4) in contact with the rind. These tactile bristles probably assist in locating a hole in the rind, or possibly discriminate between hard and soft surfaces. One specimen was observed with its ovipositor inserted within a pin hole which was made in a pumpkin and another female fly in orienting itself over this wound, would take a step or two backwards, grope around with the tactile bristles and finally push the ovipositor into the same hole. When a piece of the rind has been removed the flies apparently seek a soft area in the pulp with the tactile bristles of the ovipositor. The fruit flies will readily locate and oviposit in a slit which has been cut in the pulp.



Text Fig. 4. Distal end of the ovipositor of Dacus cucurbitæ showing the tactile bristles.

13. *Process of oviposition.*—The process of oviposition can readily be observed in the field with a hand lens. When once the fruit fly has found a suitable place, the abdomen is bent at right angles to the long axis of the body and then the distal, needle-like part of the ovipositor moves up and down in the proximal, tube-like portion. As the ovipositor is forced into the food plant, the female, in endeavoring to get a firmer foot-hold, will let go with the tarsi and claws of the middle and hind legs and grasp a new hold. The tube-like, proximal portion is thrust deeper and deeper until it disappears entirely and the eggs are then deposited. If, however, this tube has not been pushed entirely into the host plant, the eggs can actually be seen gliding through the ovipositor at the rate of one in about every fifteen or twenty seconds. Two specimens were timed during oviposi-

tion and it required seven and nine minutes respectively to complete the egg laying period.

14. *Number of eggs deposited in a receptacle.*—The number of eggs which the pest lays within a receptacle varies from one to forty. The insect often punctures various parts of the host plant with its ovipositor and yet does not deposit any eggs.

15. *Number of ripe eggs in ovaries.*—In order to ascertain the number of ripe eggs present in the ovaries, eighteen melon flies were captured in the field and dissected. The average number of mature eggs found in the two ovaries was forty-eight; the largest number of fully-developed eggs dissected from one specimen was seventy-four and the smallest number obtained from an individual was twenty-two. The number of eggs which one female is able to lay during its natural life was not determined.

16. *Duration of the egg, larval and pupal periods.*—After melon flies had been induced to oviposit in pumpkins, squash, egg plants, tomatoes, cucumbers and string beans in the field, the vegetables were transferred to breeding jars and a careful record was taken of the different periods of the life history. The following table shows the duration of the egg, larval, and pupal periods of Dacus:

TABLE I.

DURATION OF THE EGG, LARVAL, AND PUPAL PERIODS OF DACUS CUCURBITÆ.

Host	Egg period (hours)	Larval period (days)	Pupal period (days)
Pumpkin	30	4–7	10–13
Squash	32	5–7	11–14
Egg plant	31	5–11	12–14
Tomato	36	5–8	12–13
Cucumber	33	5–9	12–14
String bean	31	5–10	11–12

17. *The effect of temperature on the egg period.*—Pumpkins containing eggs which had been recently laid were exposed to the hot sunshine, while others were kept in the shade under field conditions, but no marked difference in the duration of the egg period was observed.

18. *The effect of decay of food on the rate of development of the larvæ.*—One important factor upon which the rate of development of the melon fly larvæ depends, is the rapidity of decay of

the host plant which follows an infestation of the pest. A large number of maggots in a ripe pumpkin cause decay more rapidly than a smaller number in a similar host of the same size. The following table shows a comparison of the rate development of the pest in rapidly and slowly, decaying, food plants:

TABLE II.

COMPARISON OF THE RATE OF DEVELOPMENT OF THE MELON FLY LARVÆ IN RAPIDLY AND SLOWLY DECAYING HOSTS.

Rapidly decaying hosts	Number of larvæ	Larval period (days)	Slowly decaying hosts	Number of larvæ	Larval period (days)
Pumpkin	211	3¾	Pumpkin	1	4
	201	4¾		52	5
	55	5¾		26	6
	6	6¾		8	7
				1	8
Egg plant	4	5	Egg plant	4	8
	11	6		45	9
	16	7		11	10
	38	8		1	11
Cucumber	2	5	Cucumber	6	9
	14	6			

It is possible that the rapid decay of vegetables is caused not only by the enzymes secreted by bacteria, but also by the enzymes of the saliva of the melon fly larvæ. The enzymes change the pulp into a thick liquid and it may be possible that the maggots absorb some of this food directly through the body wall. Larvæ swallowing and possibly absorbing liquified food probably would require less time to complete their development than maggots feeding upon solid food.

19. *The effect of drying food on the larvæ.*—In string beans which gradually dry up during an infestation, there is a marked individual variation in the growth of the melon fly larvæ, even when hatched from the same batch of eggs. In a dried, bean pod the larval period is longer than in a decaying one. In the laboratory the maggots often died in the seeds and the pods of dried string beans, a fact that was also observed in the field. In all probability, these larvæ died from lack of moisture due to the drying up of the string beans.

20. *Respiration of larvæ in liquified pulp.*—Melon fly larvæ in a decayed tomato were observed to obtain a fresh supply of air by pushing the posterior spiracles above the surface of the liquified pulp. The stem of this tomato had been cut out and many maggots were found suspended from the surface film with their bodies immersed in the liquid. When the finger was snapped against the tomato, the larvae wriggled down into the liquified pulp, but sooner or later, they would come up to the surface film to breath.

21. *Jumping habit of larvæ.*—When nearly, full-grown, melon fly larvæ are removed from the host, they exhibit a peculiar habit of jumping, but this behavior is not manifested by the smaller maggots. The larvæ curl the body in a circle (plate XXVIII, fig. 17), the jaws attach to the posterior end of the body, and then by a sudden muscular relaxation, they spring about six to eight inches into the air.

22. *Feeding habits of the melon flies.*—As a rule, Dacus feeds during the early morning from sunrise to about ten o'clock. During the hottest part of the day thousands of these insects may be found at rest under large leaves of plants in or near an infested field of cucurbits. The flies were frequently found several hundred feet away from their breeding grounds, feeding upon the flowers of the glue bushes, sunflowers and Chinese bananas. Not a single fruit fly was ever seen entering and feeding within the carolla of pumpkin flowers or morning glories, but after a rain, specimens were occasionally observed lapping up the small droplets of water on the lobes of the corolla of morning glories. Melon flies feed upon the juices of injured or infested cucurbits in the field. Many individuals were observed feeding on the juices exuding from sweet corn. One adult was noticed feeding on a dead and partly decomposed caterpillar.

When a piece of the rind of a pumpkin was removed, large numbers of the pest were attracted to the exposed pulp and fed upon the exuding juices. When a common house fly also visted the pulp to feed and approach a melon fly already enjoying a meal, the latter would dart forward and chase the former away, but when laying eggs the fruit fly would not withdraw its ovipositor even when the house fly crawled over its body.

23. *Do melon flies manifest fear?*—A melon fly is keenly aware of movements within its field of vision. When a large Odonata flies above a melon fly at rest on a cucurbit, the trypetid may tilt its head to follow the flying insect with its eyes. When one approaches a pumpkin slowly and carefully upon which a specimen is feeding, the fly may tilt its head and sway its body from side to side by bending the legs at the tibiofemoral joints. At such times a slight movement on the part of the observer will cause the fruit fly to take wing. The swaying movements of the alert insect may possibly be interpreted as an external indication of fear. Howlett (7, pp. 415-416) believes that this swaying movement "seems to be associated with 'courtship' in all species of Dacus that occur at Pusa." When the head of Dacus cucurbitæ is lowered, however, and the insect walks about with the wings held almost at right angles to the long axis of the body one can then approach the pest without danger of causing flight.

24. *Number of days required before the adults begin to oviposit.*—An attempt was made to determine the number of days required before the egg-laying period begins, after the melon flies issued from the puparia. A large number of adults upon emerging, were kept in breeding jars and fed on diluted molasses, fruit and vegetable juices and on water. After having been kept in captivity for eight days, three females were dissected but no fully-developed eggs were found in the ovaries. A daily dissection of three fruit flies was continued from now on, and at the end of fourteen days twenty-three ripe eggs were counted in the two ovaries of one fly, but others did not show mature eggs in the ovaries at the end of sixteen days. At the end of seventeen days, thirty-one eggs were dissected from the ovaries of another specimen. In all probability, the effect of confining the insects in breeding jars plays an important part in the rate of development of the eggs.

25. *Summary of stages of the life history.*—The duration of the different stages of the life history of Dacus cucurbitæ may be summarized as follows:

	DAYS	
Egg period	1¼— 1½	
Larval period	3¾—11	
pal period	10 —14	
laying begins	14 —17	after the adults emerge.
	29 —43½	

26. *Number of generations annually.*—In the Hawaiian Islands one brood of melon flies is followed by another throughout the year. Since the duration of the complete life cycle may vary from twenty-nine to forty three days, one would expect from eight to twelve generations a year. Assuming that a single female produces only ten descendants and that the sexes are produced in equal numbers at the end of the year she would be the ancestor of from 100,000,000 to 1,000,000,000,000 offspring.

VII. Weights of the Eggs, Larvae, Puparia and Adult Melon Flies.

Accurate weighings of the following stages in the life history of Dacus cucurbitæ were taken: eggs (plate XXXI, fig. 46) a few hours after these were deposited and again shortly before hatching; larvæ after hatching and every day thereafter (plate XXXI, figs., 47 and 52); recently, formed puparia (plate XXXI, fig. 53) and male and female melon flies.

Pumpkins, in which melon flies had been induced to deposit their eggs, were taken from the field to the laboratory and three hours after oviposition, the eggs were removed and counted in two lots, each containing one hundred eggs. Each batch of eggs was placed upon a small piece of filter paper and weighed in a weighing bottle. The eggs were then transferred from the filter paper into a pumpkin and twenty four hours later, the same eggs were removed and weighed again. The weights of the eggs three hours and twenty-seven hours after deposition were as follows:

TABLE III.

WEIGHT IN MILLIGRAMS OF EGGS OF DACUS CUCURBITÆ AFTER DEPOSITION, BEFORE HATCHING AND LOSS IN WEIGHT.

	3 hrs. after deposition	27 hrs. after deposition	Loss in wt. in 24 hrs.
Wt. of first 100 eggs....	7.2	6.	1.2
Wt. of second 100 eggs..	7.5	6.1	1.4
Average wt. of 1 egg...	.0735	.0605	.013

The result shows that each egg on an average, lost .013 milligrams in weight, during the twenty-four hours between the two weighings.

After the second weighing, the first lot of one hundred eggs was put back into the pumpkin and the second batch was placed between moist filter paper. These lots hatched respectively in thirty and thirty-two hours after deposition. The hatching of the first batch of eggs was observed under a binocular microscope in order to remove the larvæ before they had an opportunity to feed. The weight of the maggots and the difference in weight between the eggs and larvæ are recorded in the following table:

TABLE IV.

WEIGHT IN MILLIGRAMS OF RECENTLY HATCHED LARVÆ OF DACUS CUCURBITÆ, AND DIFFERENCE IN WEIGHT BETWEEN EGGS AND LARVÆ.

	Wt. of 100 recently hatched larvæ	Difference in wt. between eggs and larvæ	
		3 hrs. after deposition	27 hrs. after deposition
Hatched from first 100 eggs.....	4.2	3.	1.8
Hatched from second 100 eggs.....	5.6	1.9	.5
Average wt. of 1 larva.....	.049	.0245	.0115

The two hundred, recently hatched maggots weighed one-third less than the eggs after deposition and about one-fifth less than the eggs before hatching. This loss can be attributed, in part, to the shedding of the chorion and vitelline membrane.

The one hundred larvæ which hatched from the first batch of eggs were fed upon a hard, dry pumpkin while the other one hundred maggots were fed on a soft, juicy pumpkin. The following table shows the weights of the larvæ after they had fed a day.

TABLE V.

WEIGHTS IN MILLIGRAMS OF LARVÆ OF DACUS CUCURBITÆ FED UPON A HARD, DRY PUMPKIN AND A SOFT, JUICY PUMPKIN.

	Fed on dry, hard pumpkin	Fed on soft, juicy pumpkin	Difference in wt.
Wt. of 100 larvæ 1 day old.....	26.6	63.6	37.
Wt. of 1 larva 1 day old.....	.266	.636	.37

It is evident from this table that the larvæ which fed on [illegible]ft, juicy pumpkin for one day weighed over twice as much [illegible] maggots which fed on the dry, hard pumpkin. Further-[illegible]former had increased their initial weight over eleven [illegible] latter over six times at the end of one day.

Fifty of the one hundred larvæ which fed on the soft, juicy pumpkin were weighed at intervals of one day throughout their larval life. In order to remove all of the pulp, which adhered to the bodies of the maggots, they were carefully washed and dried with filter paper before each weighing. The following table shows the daily increase in weight of the larvæ, daily increase over the initial weight, and increase or decrease of weight over the previous day:

TABLE VI.

DAILY INCREASE IN WEIGHT, DAILY INCREASE OVER THE INITIAL WEIGHT AND INCREASE OR DECREASE IN WEIGHT OVER THE PREVIOUS DAY IN MILLIGRAMS OF THE LARVÆ OF DACUS CUCURBITÆ.

Age of larvæ	Wt. 50 larvæ	Wt. 1 larva	Increase in wt. of 1 larva over initial wt.	Increase or loss of wt. of 1 larva over previous day
At hatching.	2.8	.056		
1 day.....	31.8	.636	.58	.58 increase
2 days....	101.2	2.024	1.968	1.388 "
3 days....	801.6	16.032	15.976	14.008 "
4 days....	1021.7	20.434	20.378	4.402 "
4½ days....	1004.3	20.086	20.03	.348 loss

The daily increase in weight over the initial weight may be stated as follows:

After feeding 1 day a larva weighs 11.3 times its initial weight.

After feeding 2 days a larva weighs 36.1 times its initial weight.

After feeding 3 days a larva weighs 286.2 times its initial weight.

After feeding 4 days a larva weighs 364.8 times its initial weight.

After feeding 4½ days a larva weighs 358.6 times its initial weight.

The minimum increase over the initial weight occurred during the first day of the larval life and the maximum increase took place during the third day.

The daily increase or decrease in weight over the previous day may be put as follows:

The first day a larva acquires 10.3 times the weight at hatching.

The second day a larva acquires 2.1 times the weight of the first day.

The third day a larva acquires 6.9 times the weight of the second day.

The fourth day a larva acquires .27 times the weight of the third day.

In 4½ days a larva lost .017 times the weight of the fourth day.

The minimum increase in the daily weight of the larvæ over the previous day occurred during the fourth day and the maximum increase took place during the first day. During the last twelve hours of the larval period, the maggots decreased in weight. In all probability, this loss may be attributed in part, to the evacuation of the contents of the alimentary canal previous to pupation.

After the fifty larvæ bored out of the pumpkin in 4½ days they were allowed to pupate in moist sand. Twelve hours later the sand adhering to the newly-formed puparia was washed off and the moisture adhering to them was absorbed with filter paper. After the puparia were thoroughly dried they were weighed in a weighing bottle. Other melon fly maggots which bored out of pumpkins in 3¾ and 4 days were weighed, and twelve hours later the newly-formed puparia were weighed. The following table shows the average weights of the mature larvæ, the puparia twelve hours after the larvæ bored out of the pumpkins, and the loss in weight after pupation:

TABLE VII.

AVERAGE WEIGHTS IN MILLIGRAMS OF MATURE MELON FLY LARVÆ, WEIGHTS OF THE PUPARIA TWELVE HOURS AFTER THE LARVÆ BORED OUT OF THE PUMPKINS AND THE LOSS IN WEIGHT AFTER PUPATION.

Age of larvæ	Average wt. 1 larva	Average wt. 1 puparium	Loss in wt. after pupation	Loss in wt. %
4½ days.....	20.086	18.95	1.136	5.6
4 days.....	22.509	20.336	2.173	9.6
3¾ days.....	20.87	19.0534	1.8166	8.7

The results show that twelve hours after the melon fly larvæ bored out of the pumpkin and transformed into puparia, there was a loss of 5.6 to 9.6% in weight.

Is there a difference in weight of the male and female melon flies upon emerging from the puparia? The following table shows the weights of two lots of flies shortly after the wings were expanded:

TABLE VIII.

WEIGHTS IN MILLIGRAMS OF MALE AND FEMALE MELON FLIES SHORTLY AFTER EMERGING FROM THE PUPARIA.

Number of flies	Weight	Weight 1 fly	Difference in weight of a ♂ and ♀ fly
50♂	47.52	.9504	
50♀	48.9	.978	.0276
40♂	51.	1.275	
30♀	45.69	1.523	.248

It is evident from this table that the female melon flies are heavier, on an average, than the males shortly after they issue from the puparia.

VIII. Natural Enemies.

Predaceous insects sometimes prey upon the melon fly. At all times of the day the yellow dragon fly (Panatala flavescens Fab.) was observed flying over a pumpkin patch teaming with pest, and one would be inclined to believe that the melon flies are sometimes preyed upon by this predaceous insect. A number of dragon flies were captured in this field and the contents of their alimentary canal was examined, but no remains of the melon fly were found. A predaceous bug (Zelus peregrinus Kirkaldy) was observed sucking out the juices of a melon fly on a sunflower. Staphylinids or rove beetles were frequently seen within infested pumpkins but whether or not these feed upon the melon fly maggots was not determined.

The European, horn fly parasite (Spalangia hirta Haliday) was bred from the puparia of the melon fly. These puparia were gathered from beneath infested pumpkins; some of these puparia were partly exposed from the ground; while others were taken from one to four inches below surface of the soil, the usual depth, however, being one to two inches. From five hundred puparia which were collected on March 25, three parasites emerged on May 4, 1912. It is evident that this parasite is of little importance in the control of the melon fly.

IX. Methods of Control.

27. *Experiments in destroying infested vegetables.*—Van Dine (11, p. 35) formerly stationed at the Hawaiian Agricultural Experiment Station, recommends that all melons and vines infested with melon fly larvæ should be collected at intervals of five or six days and covered with earth to a depth of several inches.

A number of experiments were performed to determine the distance that melon flies, after issuing from the puparia, were able to burrow through sand and soil. In the first experiment several hundred puparia were placed on two inches of dry, sterlized sand at the bottom of a cylindrical, museum jar (24x11½ inches) and this jar was then filled with more of the same kind of sand. A similar vessel, half filled with dry sand, was then inverted over the top of the above mentioned jar. This was done by placing a heavy, glass plate over the mouth of the jar to be turned upside down, inverting the same above the other vessel and then pulling the glass plate out from between the two jars. A similar experiment was conducted with wet sand which had been previously sterlized. The puparia in both experiments were arranged in a circle close to the wall of the jars so that when the fruit flies emerged and burrowed through the sand their paths might be seen. When the trypetids emerged, many would bore up to the region where the jars came in contact with one another and then escape through the small spaces between the jars. These small spaces were due to particles of sand which rested on the rims of the jars. One could scarcely believe that these large flies were able to flatten their bodies to such an extent as to squeeze through such small spaces as existed between the jars.

It was evident that some of the melon flies were not able to burrow as far as others, for many died at the upper end of the channels before obtaining their liberty (plate XXXI, fig. 45). Flies would frequently bore into an excavation made by other specimens and if the union of the channels would form a more or less circular path, some of the individuals would continue to burrow slowly round and round and finally die in this endless [illegible]. Usually, however, most of the trypetids showed [illegible] orientation and bored directly upward. This nega-

tive reaction to gravity is common with many insects after emerging from the egg or pupa.

As there was a possibility that the melon flies might have been hindered by being against the glass, holes two and three feet deep were drilled in hard soil with a fence-post borer. At the bottom of these holes 500 puparia were placed. The puparia were then covered with sterlized dry or wet sand or soil. After these pits were filled each hole was covered at the surface with a large mouthed jar which rested tightly against the solid earth. The following table shows the number of melon flies which succeeded in boring through two and three feet of sand or soil:

TABLE IX.

NUMBER OF DACUS CUCURBITÆ WHICH BURROWED THROUGH TWO AND THREE FEET OF SAND OR SOIL.

Number of feet puparia were buried.....	2	3
Number of puparia buried in each hole.....	500	500
Number of flies that bored through dry sand..	34	2
Number of flies that bored through wet sand..	8	0
Number of flies that bored through soil.....	5	0

It is evident from this table that a larger number of melon flies were able to bore through dry sand than wet sand, and that very few specimens succeeded in making their way through the more lumpy soil.

Burying infested cucurbits and the vines in three feet of soil would require a considerable amount of labor. Lime, which is often thrown into the garbage-can to destroy the larvæ of the house fly and blue bottle fly, would probably destroy the melon fly maggots if it was buried in sufficient quantity with the infested vegetables, but this method would increase the cost.

In an experiment melon fly maggots were submerged in fresh water for a period varying from two to four days, in order to determine whether such larvæ would pupate and give rise to flies. Larvæ were selected which had bored out of a pumpkin and were ready to pupate. These maggots were submerged in seven inches of distilled water which was renewed daily. After remaining in the water for two, three or four days, the larvæ were transferred to filter paper and after pupation, the puparia were placed in moist sand in a breeding jar. The following table indicates the results obtained.

TABLE X.

NUMBER OF MELON FLY LARVÆ WHICH PUPATED AND ISSUED AS ADULT FLIES, THE LARVÆ BEING SUBMERGED IN SEVEN INCHES OF WATER FOR A PERIOD OF TWO TO FOUR DAYS.

Number of larvæ	Days submerged in water	Number pupated	Number of dead pupæ	Adults reared
100	2	75	28	47
100	3	16	11	5
100	4	0	0	0

From this experiment one could conclude that infested vegetables may be submerged in a barrel or tank of water for a period of four days and then plowed under without danger of having melon flies emerge from this material. By following this method a valuable fertilizer is added to the soil. Undoubtedly, certain chemicals could be added to the water which would destroy the melon fly larvæ in the infested vegetables in less time, but this again, would increase the cost.

Burning or boiling maggoty vegetables is somewhat expensive on account of the fuel consumed. The old vines in seriously, infested, cucurbit fields were often pulled out of the ground, raked together in piles, the infested vegetables were scattered within these piles and then all was burned. Some kinds of infested vegetables could be boiled and then fed to hogs.

28. *Screening or netting.*—Attempts to grow the various kinds of Cucurbitaceæ in Hawaii are carried on mostly by Japanese and Chinese. Many of these cultivators screen the newly set cucurbits with pieces of gunny sac, paper bags, newspapers or straw. Some of the growers screen their melon and cucumber beds with cheese cloth or mosquito netting but as Froggatt (5, p. 18) states, "though it kept the flies out it also kept all the bees and small insects that, under ordinary conditions, fertilize the flowers, so that very few melons ever set and matured." Hand pollination could be resorted to, but this method would require a considerable amount of labor. [illegible] individual who attempted to grow pumpkins hired a [illegible]anese who removed from the vines, the staminate flowers [illegible] seriously infested with the larvæ. Screening the [illegible]t at all practical except possibly for a few vines in a

garden. Covering the newly set cucurbits requires constant attention and cannot be recommended, if the question of labor is taken into consideration.

29 *Trap crops.*—Marsh (9, pp. 155-156) made a test of a trap crop by planting cantaloupes among cucumbers. "It was thought that the cantaloupes would prove more attractive to the flies than cucumbers, but such was not the case, as the cucumbers were more badly damaged than the cantaloupes, and in the end both crops were practically destroyed by the larvæ."

30. *Traps.*—In Honolulu a Japanese glass fly trap is used by many of the Oriental merchants to capture house flies, blue bottle flies etc.; the insects enter the trap to feed and are drowned in soapy water within the apparatus. As this trap is similar to our American style of glass fly trap, a description of the Oriental type is not necessary. A Japanese fly trap with molasses as a bait was wired in a large orange tree and in twelve days nineteen male and fifty-eight females Mediterranean fruit flies and three male and one female melon fly were found drowned in the soapy water. Two of the American style of glass fly traps with molasses as a bait were placed upon the ground in a pumpkin patch but no trypetids were caught in these. A dozen of the common, mosquito, screen, fly traps with molasses diluted either with water or stale beer as a bait were fastened to sticks above the pumpkin vines but not a single fly was found in the traps during the five days that they were kept in the field.

31. *The use of vegetable, animal and petroleum oils to trap the melon flies.*—Recent investigations have shown that certain vegetable and petroleum oils attract enormous numbers of male fruit flies of different species. Howlett (7, pp. 412 and 414) found that citronella oil has an attraction for the males of the peach fruit fly (Dacus zonatus Saund.) and the three-striped fruit fly (Dacus diversus Coq.) but the attraction in the last case, however, seems perhaps a trifle less powerful than with Dacus zonatus. Froggatt (5, pp. 13 and 17) found that the mango fruit fly (Dacus ferrugineus Fab.) is also attracted to citronella oil but that the melon fly (Dacus cucurbitæ Coq.) never came to this oil. According to Illingworth (8, p. 160) the apple maggot or railroad worm (Rhagoletis pomonella Walsh) avoids citronella oil.

We found that many of the oils derived from crude petroleum attracted the males of the Mediterranean fruit fly (Ceratitis capitata Wied.), but rarely was a specimen taken in animal or vegetable oils. Our experiment with kerosene shows that of every thousand Mediterranean fruit flies captured only three, on an average, were females, the remainder being males. It is noteworthy to mention that the Queensland fruit fly (Dacus tryoni Frogg.) and the Mexican or Morelos orange worm (Anastrepha ludens Loew.) are not attracted to kerosene.

The vegetable, animal and petroleum oils listed in the following table were poured in pans and placed upon the ground in a pumpkin patch which was swarming with melon flies. The number of pans used, the number of days each oil was tested and the results obtained are stated in the following table:

TABLE XI.

NUMBER OF MALE AND FEMALE MELON FLIES CAPTURED IN ANIMAL, VEGETABLE AND PETROLEUM OILS.

		Pans		♂	♀
Vegetable oils	Citronella	2	5 days	1	2
	Turpentine	1	16 hours	0	0
	Cocoanut	2	5 days	0	2
Animal oils	Whale	2	5 days	2	4
	Fish	2	5 days	1	1
Petroleum oils	Kerosene about 120° Bé	3	5 days	2	3
	Gasoline about 86° Bé	1	16 hours	0	0
	Benzine about 63° Bé	1	16 hours	0	0
				6	12

In all probability, the specimens were not attracted to these oils but came within the sphere of influence by accident, became stupefied and dropped into the oil.

32. *Night traps.*—As the melon flies show a strong positive reaction to light, an attempt was made to capture the pest with a night trap. Herrick's moth trap was placed in a pumpkin patch but not a specimen was caught. A seventy candle-power [illegible] lamp was placed above the moth trap and the light [illegible] were directed towards thousands of melon flies resting [illegible] sunflower leaves in the pumpkin patch but not a single [illegible] was attracted to the light.

[illegible] *poisoned bait spray.*—Striking demonstrations have [illegible] of the effectiveness of the poisoned bait spray in [illegible] olive fly (Dacus oleæ Rossi) in Italy and France

and the Mediterranean fruit fly (Ceratitis capitata Wied.) in South Africa.

Recently similar control measures have been used in the United States and Canada against the apple maggot (Rhagoletis pomonella Walsh), the cherry fruit flies (Rhagoletis cingulata Loew. and Rhagoletis fausta O. S.) and the currant or gooseberry fruit fly (Epochra canadensis Loew.). We have tested the effectiveness of the poisoned bait spray to control the Mediterranean fruit fly under Hawaiian conditions. The method adopted was to wire ten kerosene traps in different parts of an orchard containing about four hundred fruit trees. The total number of fruit flies captured in five weeks was 10,239; of this number 10,203 were males and only 36 were females. During the following five weeks the poisoned bait spray was applied to the trees about once a week. The total number of fruit flies captured in the kerosene traps during these five weeks was 182, of which number 93 were caught during the first week.

As already stated Dacus cucurbitæ requires at least two weeks under laboratory conditions before the egg-laying period commences. Under natural conditions, the flies seek food during this period and subsist on a variety of sweet substances already discussed under the feeding habits of the melon fly. In captivity, the adults show a fondness for diluted molasses and they fed on this liquid until their abdomens became greatly distended. One can readily understand that if this insect is attracted to diluted molasses under natural conditions, that the greediness of the fruit flies for this sweet when poisoned, would be the weak point in the life history to attack the pest. If this poisoned bait is applied in the form of a spray to the food plant, when the trypetids issue from the puparia, no doubt large numbers would be killed before the egg-laying period begins.

The poisoned bait was prepared according to the following formula:

Brown sugar	2½ lb.
Arsenate of lead	5 oz.
Water	4 gal.

The solution was prepared by dissolving the brown sugar and lead arsenate through cheese cloth in cold water so as to strain out all foreign material including ants, which in the Hawaiian Islands frequently gnaw through the paper sacs

containing the sugar. The mixture was thoroughly agitated by pumping the liquid back upon itself with a common, garden, brass spray-pump. To kill the enormous numbers of melon flies quickly in a badly infested cucurbit field, one ounce of a soluable poison such as potassium arsenate or sodium arsenite dissolved in a small quantity of water, was added to the solution instead of arsenate of lead. The pump was provided with a fine sprinkler nozzle which throws a fine, mist-like spray.

Shortly after sunrise the insecticide was applied to all of the foliage within the pumpkin patch and also to the vegetation bordering the same, such as glue bushes, algeroba trees, bananas, sunflowers, castor oil beans, weeds and grass. As already stated in the discussion of the feeding habits of the adults, the pest was found feeding on flowers about a hundred yards away from the breeding grounds. To spray all of the feeding grounds which often consisted of dense brushes of glue bushes, would be practically impossible. The results obtained after spraying were rather striking. Before spraying, thousands and thousands of melon flies could be found resting on the lower surface of the leaves of the sunflower and castor oil plants, but after spraying, only here and there could a specimen be found. In all probability, these living flies had recently emerged from puparia, or came in from the neighboring feeding grounds or from surrounding cucurbit fields. The soluble poisons, however, burned the foliage and can not be advocated.

A few days after the application of the first spray, all of the pumpkin vines and bean plants were pulled out of the ground and raked together in piles. The infested pumpkins were scattered within these piles and then all was burned.

To determine whether the melon flies coming from their feeding grounds or from the surrounding fields of cucurbits could be controlled, watermelon seeds were planted in a field adjacent to the former pumpkin patch. The seeds sprouted before we were able to make a vigorous campaign in surrounding cucurbit fields. The watermelon plants were sprayed with the bait, using arsenate of lead, but frequent rains washed the thin film of sugar and left the plants subject to [illegible] of the pest coming from outside sources. As [illegible] weather became settled, a fresh application [illegible] made to the watermelon plants and sur[illegible]tion, but the tender stems of many of the

watermelon plants were already infested. Whether the pest, which has been allowed to increase unmolested during the past sixteen years, can be controlled under Hawaiian conditions when one individual sprays and his neighbors do not, is problematical. In all probability, better results could be obtained with the poisoned bait spray in a well isolated cucurbit field away from the valleys where rains are less frequent during the summer months.

Marsh (9, p. 155) tested a poisoned bait spray to control the melon fly in the Hawaiian Islands. He writes, "The baits were prepared by sweetening water with molasses and adding to the solution arsenate of lead or Paris green. These baits were then applied, at frequent intervals, to the foliage of infested cucumbers with a gardener's syringe. With the aid of the syringe the poisoned liquids were shot into the air above the beds of cucumbers and allowed to fall on the foliage in fine drops. In the experiment with Paris green the application was made daily from September 9 until October 14. The formula used in this experiment was as follows:

Molasses	1 quart.
Paris green	¼ ounce.
Water	1½ gallon.

Neither the experiment with arsenate of lead or with Paris green proved effective. The flies were frequently observed feeding on the poisoned liquids, but evidently they did not relish them, and so failed to consume a fatal dose."

Fuller (6, p. 26) stationed in Natal, South Africa, tested the poison bait spray to control the Mediterranean fruit fly and melon fly. Trials which have been made in several citrus orchards to control the Mediterranean fruit fly with the poisoned bait spray "have been attended with remarkable effects, and where treatment has been applied for the melon fly which attacks, squashes, marrows, pumpkins and the like, it has proved equally successful."

EXPLANATION OF PLATES.

PLATE XXVII.

Fig. 1. Resinous lump which heals the wound produced by the ovipositor of the melon fly, in the tender stems near the growing ends of the pumpkin vines.

Fig. 2. Resinous lump somewhat enlarged.

Fig. 3. Split stem of pumpkin vine near growing end, showing the eggs deposited by the melon fly.

Fig. 4. Eggs deposited on the outer surface of the corolla and its lobes.

Fig. 5. Longitudinal section of the ovary of a pumpkin, showing the eggs deposited within a receptacle.

Fig. 6. Other pistillate bud with the corolla cut open, showing the eggs deposited on the style and inner surface of the corolla.

Fig. 7. Eggs deposited on the inner surface of the corolla.

Fig. 8. Cross section of the ovary of a pumpkin, showing the eggs deposited within a receptacle.

PLATE XXVIII.

Fig. 9. Squash showing depressions caused by the oviposition of the melon fly during the early development of this cucurbit. The tissue surrounding the receptacle in which the eggs are deposited is probably killed by a secretion, and in the further development of the cucurbit a depression results.

Fig. 10. Healed wounds due to a previous infestation of the melon fly. This trypetid is unable to puncture the hard rind of the larger pumpkins with its ovipositor, but often the resinous material covering the wound cracks and oviposition may then occur in the crevices.

Fig. 11. Depressions and healed wound in a ripe pumpkin.

Fig. 12. Pumpkin, abnormal in shape, as a result of being "stung" by the melon fly during its early development.

Figs. 13 and 14. Remains of two pumpkins which were turned over to show the side resting on the ground. After the maggots bore out of a seriously reinfested pumpkin, only the rind and seeds remain.

Fig. 15. The rind of a seriously reinfested pumpkin collapsing due to decay caused by the larvæ.

Fig. 16. When the pumpkin is not seriously reinfested with the melon fly larvæ, the rind does not collapse. Such partly decayed cucurbits often serve as hosts for other insects which complete the work of destruction.

Fig. 17. Pumpkin cut in half showing the decayed pulp and seeds, and the larvæ which have jumped out of the decayed mass.

PLATE XXIX.

Fig. 18. Resinous material which exudes from the wound produced by the ovipositor of the melon fly in the ovary of a pumpkin.

Fig. 19. Resinous substance in the constriction between the flower and the ovary where the eggs are often deposited.

Fig. 20. Discoloration on the corolla indicating the region where the fly has punctured the closed flower to deposit its eggs within the stigma or style.

Fig. 21. Discoloration on the corolla where the pest has punctured the closed flower to deposit its eggs on the inner surface of the corolla lobes.

Fig. 22. The corolla of one of the flowers has detached and dropped to the ground, leaving a black flower scar. The larvæ in this case devoured the stigmas and styles and descended into the ovary.

Fig. 23. Longitudinal sections of two ovaries showing a spongy decayed pulp caused by the maggots.

Fig. 24. The detaching from the ovary after the larvæ have devoured the stigmas and styles and descended into the ovary.

Fig. 26. Dried and shriveled pistillate bud still adhering to the pumpkin vine after the larvæ have bored out of the ovary.
Fig. 27. Pistillate bud detaching from pumpkin vine after the larvæ have bored out of the ovary.
Fig. 28. Two anthers of pumpkin flowers; one anther has been partly devoured by the maggots.
Fig. 29. After the larvæ have destroyed the anthers, the pest devours the column of the stamens.
Fig. 30. The maggots finally penetrate into the long peduncle of the staminate flowers and feed on the wall of the stalk. The flower often drops from its stalk due to decay caused by the larvæ.

PLATE XXX.

Figs. 31 and 32. String beans split open showing the melon fly larvæ feeding on the seeds and flesh of the pods.
Fig. 33. After the seeds and flesh of the string beans have been devoured the inner surfaces of the pods turn black.
Figs. 34 and 35. External appearance of the infested bean pods.
Figs. 36 and 37. Melon fly pupæ inside of pods.
Figs. 38 and 39. Melon fly larvæ which have died while attempting to bore out of the string beans, probably due to the drying of the pod.
Figs. 40 to 44. Dried and shriveled string beans after the melon fly larvæ have bored out. These bean pods do not drop to the ground but remain adhering to the plant.

PLATE XXXI.

Fig. 45. Channels in moistened sand made by melon flies after emerging from the puparia. The black areas in the channels represent flies which died in their attempt to burrow through the sand.
Fig. 46. Egg of melon fly.
Fig. 47. Recently hatched melon fly larva.
Fig. 48. Melon fly larva after feeding one day.
Fig. 49. Larva after feeding two days.
Fig. 50. Larva after feeding three days.
Fig. 51. Larva after feeding four days.
Fig. 52. Mature melon fly larva after feeding four and one-half days.
Fig. 53. Puparium of melon fly.

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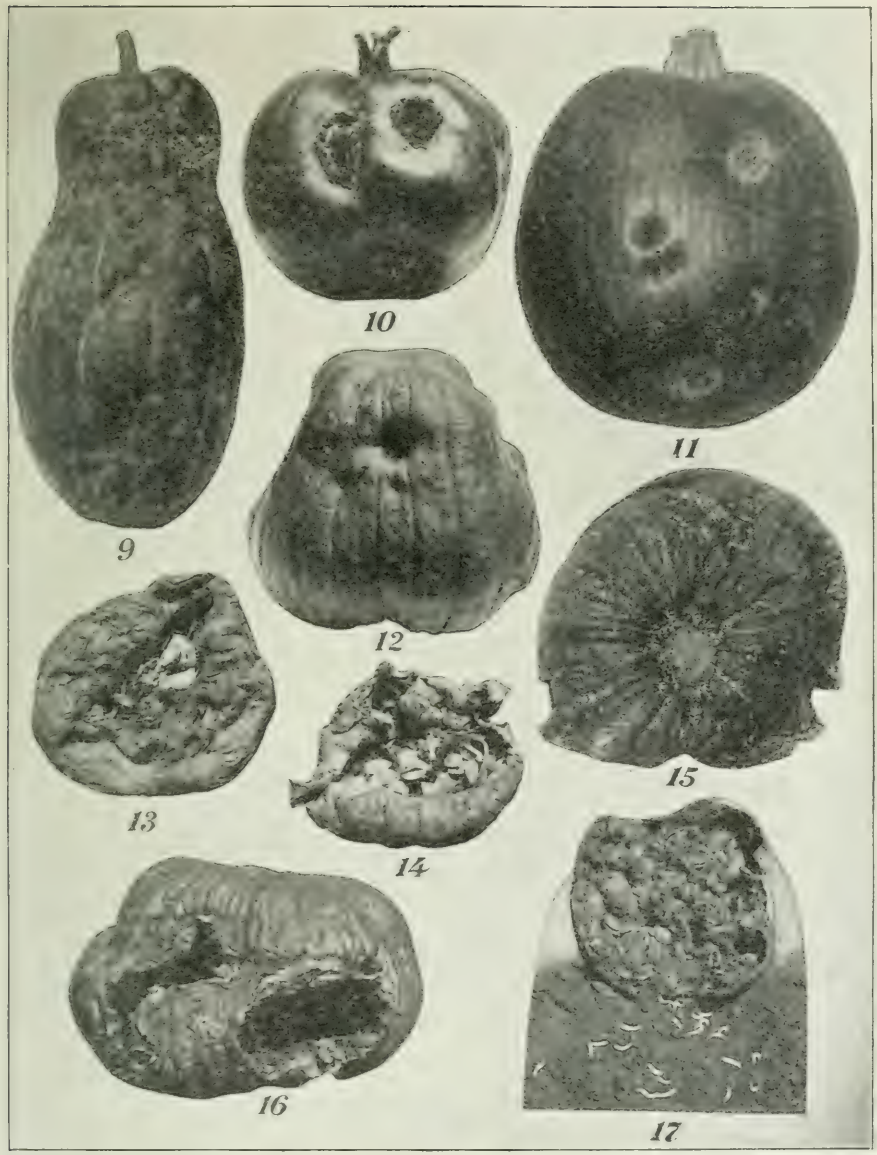

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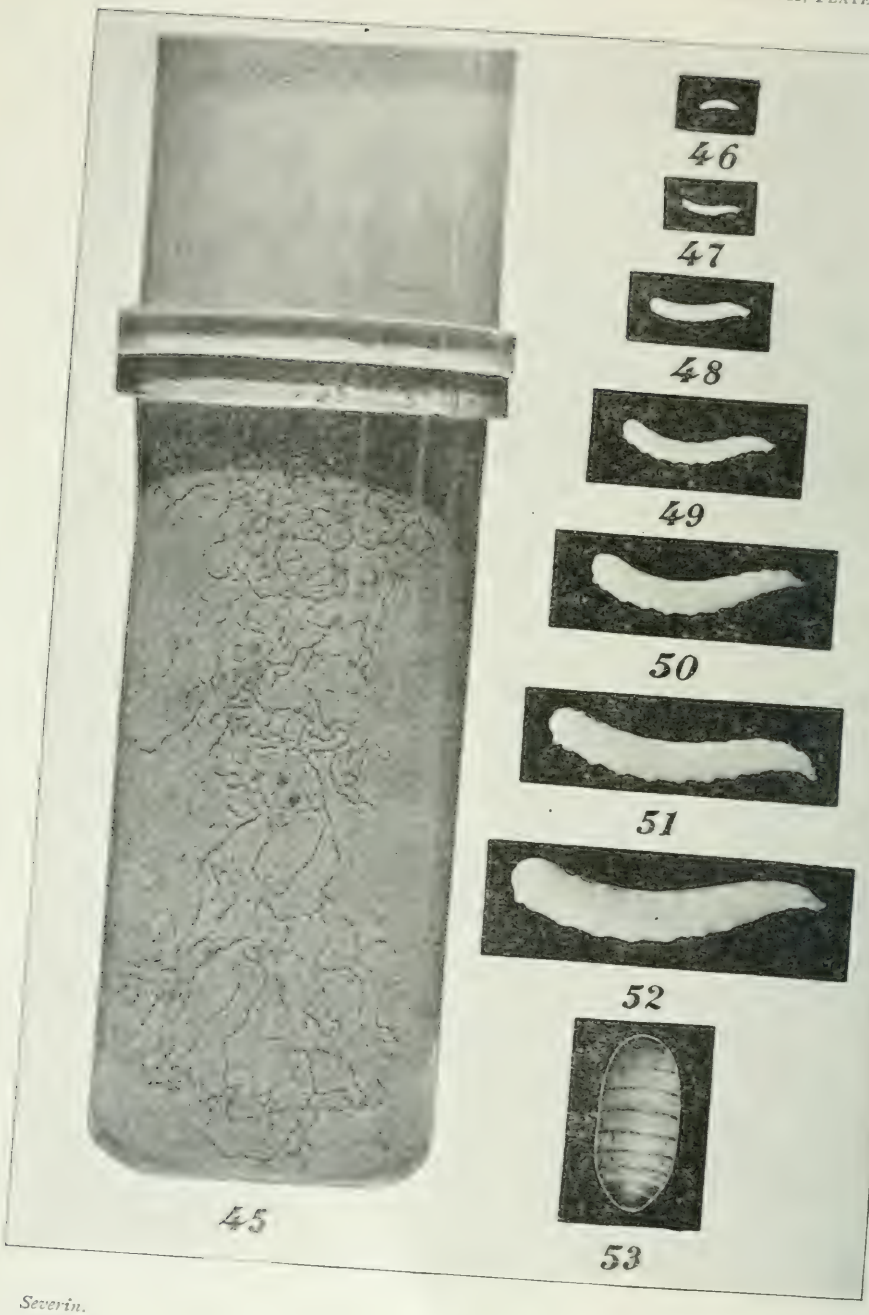


Severin.

SOME NOTES ON LIFE HISTORY OF LADYBEETLES.*

By Miriam A. Palmer

The species treated in this paper are the more common forms found in Colorado; namely, *Hippodamia convergens* Guer., *Coccinella 5-notata* Kirby, *Coccinella monticola* Muls., *Coccinella 9-notata* Hbst., and *Adalia melanopleura* Lec., *annectans* Crotch, *coloradensis* Casey, and *humeralis* Say; also incidentally, *Olla abdominalis* Say, *Hippodamia sinuata* Muls., and *parenthesis* Say, *Coccinella sanguinea* Linn., and *Scymnus* sp. Special attention was paid to the duration of the life cycle, and habits regarding egg-laying and feeding, with incidental observations on injurious influences and other points, also descriptions were made of the beetles in all stages.

Hippodamia convergens Guer.

This is our most common species, and may be described as follows:

Adult: Fig. 1, Plate XXXII.

Head black, with pale frontal spot connected laterally with the eyes; pronotum black with pale narrow border along apical and lateral margins; the two discal marks distinct and converging posteriorly; elytra yellowish red, each with a scutellar spot and with six other spots rather small in size and never united; the three posterior ones more developed and constant. The spots are frequently lacking altogether and the elytra immaculate. Legs black; length 6 to 7 mm.; width 3.5 to 4 mm.

Egg: Fig. 2, Plate XXXII.

Pale to deep amber yellow, even as deep as yellow cadmium in some cases; length 1.13 to 1.33 mm.; width .49 to .55 mm.

Larva: Fig. 3, Plate XXXII.

First instar: Entirely black with exception of pale area on lateral and dorso-lateral margins of first abdominal segment; meso- and metathorax each with two large setaceous areas and small setaceous spot laterally; abdomen with three pairs of rows of setaceous areas. Second instar: Same as first except that margins of pronotum are often pale yellowish and the pale spots on the first abdominal segment are now light orange colored, and in addition to these, faint orange spots are seen similarly placed on the fourth segment. Third instar: Same as before except that it is more orange colored in the light spots. Fourth

*This paper is an outgrowth of breeding cage work with the Coccinellids, assigned me by Professor Gillette as a part of his Adams fund project on Life Histories of the Plant Lice and Their Enemies. Acknowledgments are also due to Professor C. P. Gillette and Mr. L. C. Bragg for determination of Plant Lice herein mentioned.

instar: Same as third except for the addition of pale orange spots on the 6th and 7th segments on dorso-lateral portion, not extending laterally. Some larvæ show quite a bluish frosted appearance over the black, more especially toward the later stages. Length about 9.5 mm. for a full grown larva.

Pupa: Fig. 4, Plate XXXII.

Ground color brownish yellow throughout; pronotum with black lateral margin and an anterior and a posterior pair of black spots; wing pads black along posterior margin and over apical half; each segment with sublateral and medio-lateral spots. Spiracles black. Sometimes much lighter in general color and only a dot found on wing pad at basal third. Legs black. Length 5 mm.

Life cycle records* were made as follows:

Egg stage (22 records*) 3-7 days, mostly 3 days;
Larva stage (22 records) 10-28 days, mostly 14 days;
Pupa stage (22 records) 4-9 days, mostly 4-5 days;
Egg to adult, mostly 21 days.
Adult stage (13 records) 3-4 months for the summer generations.

A hibernating female lived 8 months and 12 days, dying May 25th, having laid eggs from April 27th to May 19th. This female would doubtless have lived longer under natural conditions. The weather was wet and unfavorable and the female was evidently in a weak or unhealthy condition as evidenced by the poor hatching of all the eggs. Another hibernating female lived until July 6th. All the females which had laid eggs before going into hibernation died either during the winter or in the spring before laying any eggs. A male which had hibernated lived 9 months and 8 days, dying June 13th.

The earliest egg record obtained was April 27th, the latest record in 1908 was September 3rd, and in 1907, was October 30th. The earliest beetles reared emerged June 22nd and the last one lived until September 22nd. Under natural conditions and in early spring, doubtless the first generation emerges as soon as the latter part of May or even earlier, according to the season. There were at least three generations obtained in a season.

The females would usually begin to lay within five days after emerging and the longest egg-laying record obtained was 1 month and 18 days. Several egg counts were made. They are as follows: 130 eggs (in 20 days), 199 eggs, 296 eggs, 312 eggs (in 1 month and 15 days), and 399 eggs, by different

*The term, record, in this sense shall be understood to mean, not notes made on a single individual, but on an egg patch and the beetles resulting therefrom.

females respectively. These numbers are certainly far below what the beetles are able to lay under favorable conditions in a state of nature. The number of eggs laid in a single batch was usually about 30, though the number varies considerably both above and below this number. When in good laying condition a female will deposit from one to two batches a day.

Food records.—Several records were taken on the feeding capacity of both larvae and adults for plant lice. One larva ate 50 *Prociphilus fraxinifolii* Riley, another half grown, ate 33 *Macrosiphum gaurae*, and another half grown, ate 105 *Chait. negundinis* Thos., in a single day. Entire counts of the whole number of lice eaten during the larval period were taken in four cases and are as follows: 264 (57 *M. gaurae*, 56 *Chaitophorus negundinis*, 151 *P. fraxinifolii*), 309 (71 *M. gaurae* 137 *C. negundinis*, 101 *P. fraxinifolii*), 585 (423 *C. negundinis*, 72 *P. fraxinifolii*, 90 *M. rosae* Linn., small), and 576 (263 *C. negundinis*, 54 *M. rudbeckiae* Fitch, 114 *P. fraxinifolii*, 57 *S. schizoneura lanigera* Hausmann, and 88 *M. rosae*), of all sizes, by each larva respectively.

A pair of beetles, male and female, ate 150 *Chaitophorus populifolii* Fitch, in one day, and 120 *Aphis setariae* Thos., on another day. A male made the following records on different days respectively: 200 *M. gaurae* Will., 30 *M. rudbeckiae*, 33 *A. torticauda* Gill., 60 *C. negundinis*, and 75 *M. cerasi* Fab., these lice being of all ages and sizes.

A female ate on different days, 36 *M. rudbeckiae*, 180 *C. negundinis*, 165 *M. cerasi*, 110 *A. helianthi* Monell, and 120 *A. setariae* respectively.

The amount eaten varied very considerably on different days. For 12 hours before molting the larvae would sometimes eat comparatively little, while for several days before pupating they would be extremely voracious. Female adults always ate the most when laying eggs. The temperature also affected their appetites very remarkably, the highest records being made on dry hot days, while in damp cool weather they often ate almost nothing.

The state and temperature of the weather was indeed a very important factor in the welfare of these insects. Cold damp weather would very much retard the rate of growth of the larvae and the egg-laying of the females and would seem to

encourage diseases. Another injurious influence was the practice of cannibalism among the larvae and also the eating of eggs and pupae by both adults and larvae. A female would often eat her own eggs. As a rule, these habits were not practiced unless there was scarcity of food and in some cases not even then, while in other cases these deeds would be perpetrated with apparently no excuse. Individuals seemed to differ widely in this respect. Some kinds of lice proved injurious in the breeding cage. Large lice such as *M. rudbeckiae* and *M. ambrosiae* Thos., caused the death of several beetles by smearing their mouths shut by means of the glue extruded from the cornicles so that the beetles starved to death. Probably the results would not have proved fatal, had the beetles not already been somewhat weakened by other injurious influences, and were it not for the unnatural conditions of the breeding cage so that the lice were restless and walking about constantly.

The larvae, especially in the younger stages, seemed to prefer smaller lice in the cages, though out of doors they were frequently found feeding on large ones with no apparent difficulty. This protective function of the cornicles, however, would probably, even in nature have more or less of an injurious effect on the beetles.

This ladybeetle seems to be a very general feeder on plant lice. One beetle was observed to eat a larva of *Aphidoletes murina*, a dipteron, which is also predaceous on plant lice, but whether it would make a practice of this in nature was not ascertained, probably not, as in other cases the larvae of *Aphidoletes* were rejected. An unusually hungry beetle or larva would often chew or suck about on the leaves which were put into the cage with the lice. They seemed to do no visible injury to the leaves and were probably only sucking and licking off the honey dew left by the aphids. Both the beetles and larvae refused to eat chrysomelid eggs and membracid larvae which were offered to them. No evidence was obtained of their feeding, to any appreciable extent, on anything besides the living plant lice. They do not seem to touch even newly laid eggs of Aphididae.

The species of aphididae which were used for food in the breeding cage were as follows: *Aphis gossypii* Glover, *A. helianthi* Dem., *A. carbocolor* Gill., *A. torticauda* Gill., *A. helianthi*

Mon., *A. pomi* De Geer, *A. cerasifolii* Fitch, *A. medicaginis*, Koch, *Phorodon humuli*, Schrk., *A. oenotherae* Oest., *A. brassicae* Linn., *Chaitophorus negundinis* Thos., *C. populicola* Thos., *C. populifolii* Fitch., *Macrosiphum ambrosiae* Thos., *M. rudbeckiae* Fitch., *M. pisi* Kalt (?), *M. rosae* Linn., *Hyalopterus arundinis* Fab., *M. cynosbati* Oestl., *Lachnus* sp., *Melanoxantherium smithiae* Monell, *Myzus cerasi* Fab., *Prociphilus fraxinifolii* Riley, *S. lanigera* Hausm, and *Melanoxantherium bicolor* Oestl.

Outdoors they were observed feeding on *A. pomi*, *M. rudbeckiae*, *C. negundinis*, *Myzus cerasi*, *Mac. on Euphorbia*, *A. atriplicis* Linn., *M. pisi*, and *M. cynosbati*. Although these were all the lice noted, *H. convergens* has been found feeding on practically all of the common plant lice; in fact, it does not seem to be at all particular, and, both because of the wide range of its feeding habits, and on account of the comparative hardiness of constitution, probably does as much or more in controlling the plant lice than any other *Coccinellid*.

Hippodamia sinuata Muls.

This species also is a comparatively common ladybeetle about Fort Collins Colorado though it does not seem to rank very high in economic importance in this vicinity.

Adult: Fig. 5, Plate XXXII.

Head black with fine apical line of whitish and median pale spot connected laterally with the eyes. Pronotum black with pale border along anterior and lateral margins with tendency to abbreviated acute line before, though this is often wanting; two converging discal marks as in *convergens;* elytra yellowish red with suture black from one to three-fourths of entire length and each with four spots, the first near humeral angle, the second, a large one, just back of the middle, near the suture, the third slightly caudo-lateral of this, and another at apical fourth, the second and third spots very often united and frequently humeral spot, also, joined to second spot by means of vitta, coalescence of third and fourth spots occasionally occurs, thus completing the entire amalgamation of all the spots; legs black; general shape rather narrow; length 5-6 mm., width 3-3.9 mm.

Egg: Fig. 8, Plate XXXII.

Amber yellow; length 1.4 mm.; width .6 mm.

Larva: Fig. 7, Plate XXXII.

First instar: Black except pale spot on lateral margin of first abdominal segment and lateral and dorso-lateral of fourth abdominal segment. Second instar: same as first except that pale spots are more pronouncedly yellowish. Third instar: same as preceding but spots

have become orange and in addition the anterior and posterior borders of the pronotum have become yellow orange (pale), also dorso-lateral spots of yellow on posterior margin of metathorax, (which seems to be a distinguishing mark in this species) and faint yellow spots dorso-laterally placed on fifth, sixth, and seventh segments, and whitish median line on all thoracic segments; length 8.5 mm.

Pupa: Fig. 6, Plate XXXII.

Ground color amber yellow covered with black except median line of yellow throughout though somewhat broken at segment margins; pronotum bordered with black; wing pads black except light spot on shoulder, meso- and metathorax with pair of black spots, abdominal segments black except median area and yellow orange spots on first and fourth segments laterally placed, fainter ones similarly placed on fifth, sixth, and seventh segments; legs black; length 5.7 mm.

Life cycle records were made as follows:

Egg stage (3 records) 3-6 days.
Larva stage (3 records) 21-23 days.
Pupa stage (1 record) 8 days.
Egg to adult, 32 to 37 days.

From these figures it would appear that the life cycle of this species was considerably longer than in the other species studied. This may, however, be partly due to the fact that these records were all made in the latter part of the summer so that the beetles were overtaken by cool weather towards the end of the larval stage.

In nature this species does not seem to be a very general feeder, being found, by Mr. Bragg, almost exclusively in the grass, or more especially on the *Carex*, feeding on *Rhop. braggii* Gill., and *Callip., flabellus* Sanb. In the breeding cage, however, it readily fed on *Mac. rudbeckiae*, *Mel. Smithiae*, *Aphis cornifolii*, *Rhop. pastinaceae* Linn., *Aphis heraclei* Koch, and *Chait. populicola*.

Hippodamia parenthesis Say.

This species ranks about equal with *H. sinuata* in economic importance.

Adult: Fig. 9, Plate XXXII.

Head black with pale abbreviated median dash from the front and a pale mark each eye, usually connected with median line, sometimes entire front portion of face pale; thorax black with anterior and lateral margins and median abbreviated acute line before white, also square spot on each elytra pale reddish with yellowish area in middle of posterior margin with common large spot near the base connected with lateral and each with humeral spot, and pair of parenthesis shaped

dashes on posterior half sometimes united into a single large lunule; legs blackish to black, tarsi brownish; general shape, somewhat pointed posteriorly; length 4-5 mm., width 2-3 mm.

Egg: Fig. 10, Plate XXXII.

Amber yellow; length 1 mm., width .4 mm.

Larva: Fig. 11, Plate XXXII.

First instar; general color grayish or blackish; head shining black except medio-anterior portion, setaceous spots black, as in all the other species reared, dorso-lateral and lateral portions of first and dorso-lateral portions of fourth abdominal segment pale, nonsetaceous portions of thoracic segments rather pale. Final instar; head black except medio-anterior portion, which is brown; pronotum bordered with pale, meso- and metathorax with whitish median portion; yellow markings as follows, lateral and dorso-lateral spots on first and dorso-lateral spots on fourth abdominal segments orange yellow, and faint indications of dorso-lateral spots on fifth, sixth, and seventh segments pale yellow; length 8 mm.

Life cycle records were made as follows:

Egg stage (1 record) 3 days.
Larva stage (1 record) 11 days.
Pupa stage (1 record) 6 days.
Egg to adult, 20 days.

This life cycle appears relatively short, but this is probably due to the fact that this batch was reared in July when the weather was specially favorable.

This species, like *H. sinuata*, has been found chiefly in the grass and *Carex* feeding on *Rhop. braggii* and *Chait. fabellus*, tho in the breeding cage it seemed to thrive on *Rhop. pastinceae*.

Coccinella 5-notata: Kirby.

Ranking next in order, or perhaps equal with *H. convergens* in economic value, is *Coccinella 5-notata*. This is somewhat larger and more robust species and may be described as follows:

Adult: Fig. 12, Plate XXXII.

Head black with triangular pale spot next each eye; pronotum black with subquadrate pale spot at the anterior angles; elytra brownish red, marked with common subbasal fascia and a transverse spot on each elytron before the middle, near the suture, and another at apical fourth. Sometimes the subbasal fascia is broken into three spots, sometimes there is also a dot on the anterior lateral portion of the elytra. Length 5.5 to 7.5 mm.; width 4.5 to 5.5 mm.

Eggs: Fig. 13, Plate XXXII.

Light to deep amber yellow in color; length 1.31 to 1.37 mm.; width .53 to .60 mm.

Larva: Fig. 14, Plate XXXII.

Indistinguishable from that of *H. convergens* until it reaches the third or fourth instar when the head becomes pale, except on the posterior and lateral margins, which remain black. Also, the yellow spots on the abdomen are usually a deeper orange color and the dorso-lateral spots on the 6th and 7th segments are lacking. The light blue frosted appearance is sometimes more pronounced than in *H. convergens*. Length about 12 mm., for a full grown larva.

Pupa: Fig. 15, Plate XXXII.

Ground color pale brownish yellow, tinged in places with pinkish, paler as a rule, than in the case of *H. convergens*. Pronotum with narrow black margin all around, except on median posterior portion; wing pads black on posterior and apical two-thirds of anterior margin, also two spots, one at basal third, and the other at apical third. These spots often coalesce, darkening the whole apical two-thirds of the wing pad. On the metathorax is a pair of black spots on the posterior margin, medio-laterally placed; spots similarly placed on 2nd to 7th segments inclusive, which segments also show another spot just within the spiracles which often runs into the first mentioned spots along the posterior margin. On the 3rd segment, the black often covers the entire surface clear to the lateral edge, leaving only a pale line on the median. Seventh segment often pale or nearly so. The amount of black varies somewhat and is often less extensive, but the pupa can usually be distinguished from that of *H. convergens* by the more extensive black markings, and by the paler ground color, but this does not always hold. Legs black. Length, 6 mm.

Life cycle records were made as follows:

Egg stage (15 records) 3-5 days, mostly 3 days;
Larva stage (13 records) 11-19 days, mostly 13 days;
Pupa stage (12 records) 3-8 days, mostly 4 days;
Egg to adult, mostly 20 days.
Adult stage (4 records) 2-3 months for the summer generations.

The efforts to carry this species through hibernation all resulted in failure, but seven beetles were captured before May, 19, 1908, which, in all probability, had hibernated, as no larvae had been observed before that time or for some time afterwards. The last of these beetles lived until August 14th, and must have lived for nearly a year, as the beetles in the cages which went into hibernation began to emerge August 6th. In the cage of these seven captured beetles, eggs were found from May 19th to August 7th, a period of two months and eighteen days.

Egg records were made as follows: 368 eggs (in 2 months and 0 days); [illegible] eggs (in 1 month and 11 days), 532 eggs (in 1 month [illegible]), 539 eggs (in 1 month and 2 days) respectively. Single egg batches often contain as many as 60 eggs; the

average size, however, would be nearer 30 to 50. A beetle in good laying condition would often lay one or two batches a day, though in the breeding cage this rate was not kept up very long at a time.

The female would usually, under favorable conditions, begin to lay from four to ten days after emerging and continued in one case for one month and eleven days, and in another, the longest record, for two months and fourteen days. The third generation was reached in a season in the breeding cage and both 2nd and 3rd generation beetles went into hibernation but none survived, the hibernating quarters being unsatisfactory. The earliest eggs obtained in the spring were found May 19, 1908; the first generation began to emerge June 17th, and their first eggs were laid June 26th. The last of this brood lived until September 21st. The latest record of eggs obtained was September 14th. That year there was much cold wet weather during August, which very considerably checked the egg laying so that the beetles would very probably have laid for at least a month later under favorable conditions.

Records on the feeding capacity of both larvae and adults were taken as follows: One larva ate 595 and another 621 aphids during the entire larval period. The lice used in these counts were of all ages and sizes. One ate *C. negundinis* 333, *M. gaurae* 24, *P. fraxinifolii* 128, and *M. rosae* 110, total 595; the other *C. negundinis* 445, *M. gaurae* 18, *P. fraxinifolii* 88, and *M. rosae* 70, total 621. These lice were of all sizes. It will be seen that *C. negundinis* was used more than any other one species. One larva made the following records on single day counts: during the first instar, 30 *C. negundinis* in a day; 2nd instar, 84 *C. negundinis*; 3rd instar, 100 *C. negundinis* in a day. These were days when all was favorable and the larva was on full feed. An adult female when in best condition ate 200 *A. helianthi* in a day.

The plant lice used for feed were the same as used for *H. convergens*. This species seems to be just as general a feeder as *H. convergens* and, being somewhat larger, would naturally be expected to consume a few more lice, but it seemed to be more delicate in constitution so that it succumbed more easily to unfavorable conditions in the breeding cage. This species was affected by the same injurious influences as were mentioned for *H. convergens*.

In 1907 and 1908 this species, from casual local observations, seemed to rank next to *H. convergens*, which was first in numbers, but in 1909 it seemed to rank about fifth, with *H. convergens* sixth. During this year, the first in numbers seemed to be *C. monticola* which, during the two previous years, had ranked third.

Coccinella monticola Muls.

This species is quite similar in general appearance to *C. 5-notata* and may be described as follows:

Adult: Fig. 16, Plate XXXIII.

Head black with triangular spot next each eye as in *C. 5-notata;* pronotum black with quadrate pale spot at the anterior angles; elytra brownish red, with common scutellar spot, and on each a broad transverse oblique median fascia and a shorter subapical one black. Sometimes the median fascia is broken, leaving a small spot laterally. Legs black. Length 5 to 7.5 mm.; width 4 to 4.75 mm.

Egg: Fig. 17, Plate XXXIII.

Same as in *C. 5-notata.*

Larva: Fig. 18, Plate XXXIII.

Same as in *C. 5-notata*, except that in 3rd and 4th instars the head is pale clear to the posterior margin, while *C. 5-notata* almost always has a line of black along the posterior margin. Length of full grown larva about 12 mm.

Pupa: Fig. 19, Plate XXXIII.

Ground color pale brownish yellow, usually paler than in *C. 5-notata*, sometimes with pinkish spots on lateral portions of 1st and 4th segments of the abdomen where the orange spots were in the larva. Black markings were as follows: Three spots on anterior edge of pronotum, and one on posterior lateral margin, wing pads with two transversely duplex spots, one at basal third and the other at apical third, and a spot at base close to posterior lateral margin, which margin is also black; median pair of spots on metathorax, also on 2nd to 6th abdominal segments inclusive, smallest on 2nd; 3rd to 6th abdominal segments also with spot within spiracles largest on third and inclined to extend to the very margin of the segment. Knees black, remainder of legs usually paler. Length 6.5 mm. The pupæ of this species can usually be distinguished from those of *C. 5-notata* by the less extensive black markings, though the two species vary so as often to be indistinguishable.

Life cycle records were taken as follows:

Egg stage (17 records) 3-8 days, mostly 4 days;
[illegible] stage (11 records) 12-14 days, mostly 13 days;
[illegible]age (11 records) 4-8 days, mostly 6 days;
[illegible]lt, mostly 23 days.
[illegible]2 records of summer generation) 2 months and 6 days, and
[illegible]nd 12 days respectively.

Three beetles captured July 15, 1907 hibernated and the last one died August 31, 1908, 13 months and 16 days from date of capture. In this cage, during 1907, only four eggs were laid, though it contained 9 beetles, but after hibernating, eggs were laid rather abundantly, though they were infertile, by one or more of the surviving three from May 11, 1908 to July 18, 1908, a duration of 2 months and 7 days. Three other beetles which were captured May 15, 1908, and in all probability had hibernated, lived until September 8, 1908, so they must have been a year old, at least, eggs having been laid from May 18, 1908 to August 18, 1908, a period of three months.

No egg records were taken on this species, as only captured females laid at all satisfactorily and these had doubtless laid a portion of their eggs while still out of doors, so a complete record could not be gotten. The earliest eggs obtained in the spring were found May 11, 1908, laid by females which had hibernated in captivity; June 16, 1909, from captured females. The latest record obtained in the fall was September 3, 1909, but as this was the only year that a record was taken and as August was very wet and cool, the beetles would probably be able to lay for a month later, at least, under favorable conditions.

The earliest generation reared emerged June 24, 1908, and began to lay July 17, 1908, and the last beetle died September 15, 1908, probably due to the unfavorable weather. Later batches of the same generation which emerged July 4, 1908, later went into hibernation but died during the winter. Beetles emerging July 5, 1909, the earliest generation obtained that year, went into hibernation.

It seems that this species may have both one and two generations in a year, since some of what were evidently first generation beetles went into hibernation while others of this same generation laid eggs, infertile though they were, and died before winter.

In feeding capacity they were about the same as *5-notata*. One larva from time of hatching to pupation ate 388 plant lice, (23 *A. torticauda*, 65 *C. negundinis*, 165 *C. populicola*, 90 *A. setariae*, 45 *M. ambrosiae*); another ate 376 plant lice, (12 *A. torticauda*, 120 *A. setariae*, 174 *C. negundinis*, 40 *C. populicola*, 30 *M. ambrosiae*). another ate 901 plant lice, (150 *A.*

gossypii, 480 *A. helianthi*, 19 *A. setariae*, 82 *C. populicola*, 140 *A. pomi*, 30 *M. rudbeckiae*); and another, 962 plant lice, (774 *A. gossypii*, 108 *M. pisi*, 80 *Myzus cerasi*). One larva during the first instar ate 30 *A. gossypii* in a single day; in the 2nd instar, 100 to 130 *A. gossypii*; third instar, 150 *A. gossypii*. Of course these records were made when all conditions were favorable. No records were taken on the adult.

The range of feed seemed to be the same as for *H. convergens* and *C. 5-notata*. They were observed out doors feeding on *A. pomi*, *H. arundinis*, *M. cynosbati*, and *S. lanigera*. Though these were the only observations recorded they seem to feed on practically every common species of plant lice.

As to injurious influences, they seemed to be affected by the same factors as the foregoing species but seemed to stand cool wet weather rather better. Some of these beetles got rather badly pasted up by the glue from the cornicles of *M. rudbeckiae* but it did not result fatally. One beetle was found with one front foot glued fast to its head, probably the result of an attempt to clean itself for which operation the beetle was not sufficiently vigorous, the foot sticking fast until it dried.

A nearly full grown larva was observed to attack a good sized pupa of *M. ambrosiae*, biting it in the side of the third abdominal segment. The louse immediately struck the larva in the face with its cornicle and discharged a quantity of glue. The larva paid no attention to this but continued until it had finished the louse, and, inside of fifteen minutes, every trace of glue was removed. Evidently when the beetles and larvae are in vigorous condition this protective device of these aphids produces little result beyond temporary annoyance.

This species seems to be peculiar in several points of its life history as compared with the other *Coccinellidae* studied; first in the fewer generations in a season, and the consequent greater longevity of the beetles; and second, in the non-activity of the males. Mr. Bragg, who had dissected at least 100 *monticola* specimens, found only one male and he has some doubt as to its really being this species. No *monticola* has been observed in coition either indoors or out except with *C. 9-notata* or *C. 5-notata* males. The eggs of a female captured mated with *C. 9-notata* all proved infertile, even though the male was kept with the female for over two months and was frequently

observed in coition and the female laid a considerable number of eggs. A male of *9-notata* was introduced into a cage of *monticola* which had been laying infertile eggs and though he mated readily no fertile eggs were produced. One female *monticola* was taken in coition with a male *5-notata*. The eggs were fertile and produced all *monticola*, but this female may have been previously fertilized by another male so there is no evidence that the *5-notata* male had any effect.

There is a possibility of the males being weaker than the females and so being killed in the struggle for existence before they matured in the breeding cage, since about 50 per cent. were, as a rule, lost when a number were reared together. All the larvae from several batches were reared in individual cages. In this way 90 percent were brought to maturity and in the adult state all were put together in the same cage, but they always died down to the usual 50 percent before there was time for sexual development to be really completed, so that there is a probability in these cases of the males having been lost because of having a more delicate constitution than the females. This would also account for their scarcity out of doors.

Two batches were reared in individual cages, maturing 17 beetles from 18 larvae and 12 beetles from 23 larvae respectively. These beetles were not put together but were dissected by Mr. L. C. Bragg as soon as mature, the first lot proving to be 7 male and 9 female and the second lot 9 male and 3 female. This latter case seems evidence against the possibility of the males being weaker than the females, as in this batch little over 50 percent matured and 75 percent were males. The only explanation remaining seems to be a sexual non-activity for some reason.

A good share of the females captured proved to be infertile, when, however, a female is once fertilized it seems to suffice for the season. Females captured May 15, 1908, laid fertile eggs until August 18, 1908, a period of over three months, after which they very soon died.

In spite of this seemingly weak point in its life history, this beetle seems to rank quite high as an enemy of plant lice.

Coccinella 9-notata Hbst.

Description of adult, Fig. 20 Plate XXXIII.

Head black with pale triangular spot next each eye, or these spots may be connected so as to form a broad white band across the face; pronotum black with quadrate pale spot at anterior angles, and apical margin usually pale, often broadly pale; elytra bright brownish red or red ochre, with common scutellar spot, and each with four other spots, the two small ones sometimes connected by a fine line, one in humeral angle and the other near the lateral margin before the middle, and two large ones, one near the suture and before the middle, the other rather transverse and near the apex. Length 6-7.5 mm.; width 5-6 mm.

Egg: Fig. 21, Plate XXXIII.

Same as the foregoing species except, perhaps, a little smaller on the average.

Larva: Fig. 22, Plate XXXIII.

First instar: Entirely black or blackish gray, except pale dorso-lateral spots on first abdominal segment, and with setaceous tubercles as in the foregoing species. Second instar: Same as 1st except that median and anterior portion of head and anterior and posterior margins of pronotum are slightly pale or dusky, the spots on the first abdominal segment more yellow, and paler spots begin to show similarly placed on 4th abdominal segment. Third instar: Same as last except that pale portions of head and pronotum are lighter, and spots on abdomen are more orange colored. Fourth instar: Same as last except pale portion of head which is light yellow. The larvæ of this species seem to be identical in appearance with those of *5-notata* but do not grow to quite as large a size. Length of full grown larva 9.5 mm.

Pupa: Fig. 23, Plate XXXIII.

Ground color light reddish or brownish yellow, often with pinkish spots on 1st and 4th abdominal segments where the orange spots were located in the larva. Pronotum with a pair of black dashes on anterior margin, and a pair of black dots on the posterio-lateral margin; a median pair of black spots on metathorax and 2nd to 7th abdominal segments inclusive; Spiracles black; Wing pads with posterio-lateral margin black and a round black spot at basal third. This marking of the wing pad is comparatively constant and nearly always distinguishes it from all of the foregoing species, though sometimes this spot seems to spread apically so that the pupa cannot be distinguished from *5-notata*. Length about 6 mm.

Life cycle records were taken as follows:

Egg stage (14 records) 3-6 days, mostly 4 days;
Larva stage (8 records) 10-21 days, mostly 11-14 days;
Pupa (8 records) 4-5 days, mostly 5 days;
Egg to adult, mostly 20-23 days.
Adult (7 records) 2 to 3 months for the summer generations.

Some of the beetles which went into hibernation were then nearly four months old but did not survive the winter, probably on account of improper winter quarters. Only one beetle survived. It had emerged September 14, 1908, and lived until April 9, 1909

Four egg records were taken as follows:

435 eggs (in 1 month and 9 days); 493 eggs (1 month and 22 days); 950 eggs (in 2 months and 22 days); and 1047 eggs (in 2 months and 14 days). They laid from 40 to 68 eggs a day when in full laying condition. Some of these beetles began to lay as soon as one day after emerging. Others began at 7 days, and one at one and a half months after emerging. This latter was in all probability not normal.

The 2nd generation was reached in the season when the experiments were carried on, but, as a rather late start was made in the spring, it is more than probable that they are able to attain to the third generation when the spring is early. The earliest eggs obtained were June 11, 1909 and the latest record was September 2, 1909.

No exact feeding records were made with this species, but judging from general observation they seemed to consume as much as the foregoing species. Being as a rule somewhat smaller than *5-notata* and *monticola*, they probably ate a little less. They seemed to take to the same range of feed as the foregoing species in the breeding cage. This species seemed to be susceptible to all of the injurious influences already mentioned and besides these, several cases of parasitism were observed in beetles captured out of doors. After emerging, the parasite formed a silky cocoon underneath the beetle. The beetle, though still alive, seemed unable to leave the cocoon of its enemy and clasped it with all of its feet as though to protect it. One was carefully examined and found to be perfectly free from any attachment and the only reason for its remaining there seemed to be a partial paralysis. When taken off the cocoon, which was accomplished with considerable difficulty because of the beetle holding so persistently with its tarsi, the beetle seemed to be unable to walk or even stand, and when offered food it made vain attempts to eat. It seemed absolutely helpless from inability to co-ordinate its movements.

There were no serious results in this species from the glue thrown out from the cornicles of the large species of lice but this was probably only accidental and not because of any specific resistent character. Once, a small larva, apparently in the second instar, was observed to seize a full grown apterous *Macrosiphum ambrosiae* which appeared to be three times the size of itself. It first caught it by the right hind foot. The louse struggled, dragging the larva about for a minute or two and extruded glue from the left cornicle. The larva then managed to get hold just behind the right cornicle and proceeded to feed on the louse, though dragged about somewhat by the latter. Two and a half hours later it was found still feeding on the louse, which was still living, but had extruded no glue from the right cornicle on which side the larva was holding it. Unless for some reason the right cornicle contained no glue, this action of the louse seems to be explained only by awkwardness or stupidity. Indeed, the cases were extremely few when the louse seemed to make any well directed effort to smear its enemy.

Perhaps next in order might be classed several forms of *Adalia* Muls., namely, *melanopleura* Lec., *annectans* Crotch, *coloradensis* Casey, and *humeralis* Say. As these four forms interbreed freely and seem to be identical in life history it seems best to treat of them here as one species, which indeed they undoubtedly are. In the descriptions of the adults, however, they must be treated separately. In the larval and pupal stages they seem to be identical in appearance but in the adult state are strikingly different.

For full description of adults of these forms, see Annals of the Entomological Society of America, Volume 4, page 283.

Egg: Fig. J, Plate XIX*.

Pale to deep amber yellow in color as in the foregoing species. Length about 1 mm.; width about .5 mm.

Larva: Fig. I, Plate XIX*.

First instar: Head and pronotum shining black, rest of body dull black or dark grayish with a median row of paler spots from pronotum [illegible] of abdomen; 2nd instar, the same except lateral and mediolateral whitish spots on 1st abdominal segment and a median pair [illegible] spots on 4th abdominal segment; pronotum bordered all around with whitish and with median pale line; 3rd and 4th instars; color often blackish gray or blue; median and anterior portion of head

dusky or pale, a pair of pale spots on anterior lateral margin and three on posterior margin of pronotum; also a pale median line, and pale median portion of meso- and meta-thorax quite noticeable; spots on abdomen more noticeable than in previous instars. Legs black. Length of full grown larva 8-9 mm.

Pupa: Fig. H, Plate XIX*.

Ground color pale to sordid flesh color, tinged in places with brownish. Pronotum with pale median line and broad lateral portion pale, remainder dusky to black. Wing pads brownish to black, meso- and meta-thorax dusky to black except median pale line; each abdominal segment with three pairs of rows of dusky to black spots, median row lighter on 1st and 2nd segments, giving a lighter appearance to that part of the pupa. In dark specimens the markings are so extensive as to almost coalesce, giving quite a melanic appearance. Legs brownish to blackish. Length 4-5 mm.

Life cycle records were taken as follows:

Egg stage (84 records) 3-7 days in the spring, 2-6 in summer, mostly 3-5.
Larval stage (68 records) 11-18 days in the spring, 7-18 summer, mostly 15 spring and 11 summer.
Pupa stage (68 records) 5-9 days in the spring, 3-9 summer, mostly seven.
Egg to adult, mostly 21 to 23 days.
Adult (9 records) 1 month to 4 months, for the summer generations.

The records taken in the spring, April and May, it will be noted, covered more days than those taken in the summer, owing to the cooler temperature. Five beetles of first to third generation that had laid a considerable number of eggs and were from three to four months old, went into hibernation. One of these lived until April 4th the next spring, aged 8 months and 6 days. The rest died during the winter, though the hibernating quarters were excellent. As there is a probability that the first female captured, May 13, 1910, and with which the start was made in the breeding cage, was not a hibernating female, there is some uncertainty as to the number of each generation. The beetles which survived hibernation were the 4th or 5th generation and they survived in large numbers, about 150 beetles in all.

A pair of beetles, the female of which was 3rd or 4th generation *humeralis* that had laid no eggs, and the male 2nd or 3rd generation *annectans*, hibernated successfully, and in the spring the female laid eggs abundantly until June 12, 1911, and they both lived until June 16, 1911, the female aged nine months and the male nine months and four days. Almost all of the hibernating beetles which were cared for were still living May

23, 1911, aged about eight months, and a number were living June 12, 1911, but all died soon after, some being nine months old or more.

The females would usually begin laying about six days after emerging and continue for about three weeks. One continued for three months, by far the longest record made, but probably the most nearly correct as most records were doubtless cut unnaturally short on account of the great difficulty of keeping the beetles healthy in captivity. The hibernating females of all the three forms began to lay in six days after having been brought in from hibernating quarters and given food.

There seemed to be at least four, and possibly five generations during the season that the experiments were carried on, though 3rd generation and possibly 2nd generation individuals hibernated successfully. There was no evidence of any females which had laid eggs before winter hibernating and laying again in the spring, though it may possibly take place. The hibernating quarters used for these beetles were excellent and apparently gave the beetles every chance.

The earliest eggs were obtained April 10, 1911, and the first of the first generation reared emerged May 8, 1911. The latest eggs in the fall were obtained September 16, 1910, but if there had been no prematurely cold weather, the beetles might have kept on laying for several weeks longer. From two or three tests made, a female seemed not to be able to lay fertile eggs longer than three or four weeks after being separated from a male. If a new male was introduced, however, it seemed to affect the eggs almost immediately and after two or three days none of the progeny showed any of the characters of the former male, even when little or no interim existed between the males.

No feeding or counts were taken on this species as all the time in the work with these beetles was used in heredity investigation * and only such life history data as took but little time were noted. On general observation it was evident that they eat much less than the foregoing larger species, and in the breeding cage, at least, will not eat as large lice as the above ladybeetles. Probably out of doors, when the lice are quiet instead of restless as in the cages, they may feed upon

* Notes on Heredity in the Coccinellid Genus, Adalia Muls." Ann. Ent. Soc. of Am., Vol IV, No. 3.

larger species. Mr. Bragg says that he found them in numbers with *Prociphilus fraxinifolii*, a species which, from their large size and great quantities of honeydew, would have certainly brought disaster in the breeding cage, for great care had to be exercised in feeding these even to the larger species of beetles. They seemed to thrive in confinement on *C. negundinis*, *A. setariae*, *A. helianthi*, *C. populifolii*, *C. populicola*, *M. sanborni* Gill., *Myzus persicae*, Sulz., *Rhopholosiphum pastinacae*, *Aphis heraclei* Koch, *M. cynosbati*. Outdoors they were found with *P. fraxinifolii*. n 1910 and 1911 this species seemed especially abundant. In the spring of 1910 the box-elders were extremely lousy but by June 26, it was extremely difficult to find any *C. negundinis* excepting the dimorphic form which the ladybeetles seemed unable to eat. This species of beetles, together with Syrphus larvae, seemed to be chiefly responsible for the destruction of the lice. Again this spring, 1911, they seem to be the chief factors in cleaning up the box-elder lice which were almost killing some trees.

These beetles seemed to have a more delicate constitution than the other species reared and had to be tended with more care, and even with the best care, hardly 25 percent could be matured, and often less in the pure strains. The hybrids were much more vigorous, and of them it was often possible to rear 50 percent to maturity. These beetles were susceptible to all of the injurious influences which have been named, and besides, they seemed to object to what might have been an odor left by a certain species of ants, as the cottonwood *C. populifolii*, which is abundantly attended by ants, was rejected at times and accepted at others with no other apparent reason. On the occasion of rejection they would turn cannibal and almost the entire cage of larvae would be lost in one day, as though they had been left without any feed at all. It seems, however, that in spite of their seemingly rather frail constitution, they hold their own in nature pretty well, as during 1909 and 1910 and the spring, at least, of this year (1911) they ranked high in comparative numbers out of doors and doubtless have been very beneficial.

Olla abdominalis Say.

This species is sometimes found, though it is rather rare. One larva was found on a boxelder tree with *C. negundinis* June 25, 1909, and was reared to maturity. It was taken when nearly full grown.

Larva: Fig. 25, Plate XXXIII.

General color black, except medio-anterior portion of the head which was pale yellow to dusky; anterior portion of pronotum and median spot on posterior margin pale; median spots of pale yellow on meso-and meta-thorax; dorso-lateral yellow spots on first abdominal segment, and dorsal and dorso-lateral on 4th abdominal segment; lateral tubercles pale or partly so. Median pale spot on median posterior margin of each segment becoming larger toward caudal end of abdomen and giving the appearance of a pale median longitudinal line the entire length of the abdomen. Legs black.

This larva resembled the *Adalia* larvæ very much but grew to be somewhat larger than they did. Length of full grown larva 10 mm.

Pupa: Fig. 26, Plate XXXIII.

Ground color whitish tinged with yellowish and brownish in places. Markings as in *Adalia*. Length 5 mm.

Adult: Fig. 24, Plate XXXIII.

Head white except two black spots on the posterior margin; pronotum with (M) design as in *Adalia*, but with the white more extensive so that the pale spots often run together in places; elytra pale maize yellow, each with a row of four basal spots, a row of three just before the middle, the inner one crescent-shaped, also one subapical near the lateral margin. Sometimes this apical spot and the middle row are all connected into a triangular black patch. Legs brownish yellow. Length 4-6.5 mm.; width 4-5 mm. No work has been done with this beetle further than the rearing of the one larva found. This larva was found with *C. negundinis* on boxelder.

Coccinella sanguinea Linn.

This seems to be the species designated by Casey as *Cycloneda rubripennis* Casey, and by C. W. Leng as Subgenus *Cycloneda sanguinea* var. *rubripennis* Casey.

This species is comparatively if not indeed quite rare about Fort Collins, Colorado, but seems to occur more plentifully in the vicinity of Boulder, Colorado.

Adult: Fig. 27, Plate XXXIII.

Head black with broad white border next each eye, often also median pale spot and in many cases entire front of head white; pronotum black with rather narrow pale border along sides and extending posteriorly and internally along the base to about lateral sixth, apical pale line quite narrow with median acute line often rudimentary, also isolated subapical pale spot which is sometimes narrowly connected to

the pale apical margin; elytra deep and bright scarlet with transverse pale spot on each side of scutellum; legs black to brownish, tarsi brownish; general shape broadly oval and rather strongly convex. Length 4.5 to 5.5 mm.; width 3.5 to 4.75 mm.

Egg: Fig. 28, Plate XXXIII.

Pale amber yellow; length 1.36 to 1.5 mm.; width .63 to .7 mm.

Larva: Fig. 30, Plate XXXIII.

First instar: Black or dusky with pale lateral spot on first abdominal segment, setaceous spots black as in other species. Second instar: Same as first except that fourth abdominal segment shows pale lateral and dorsal spots, and sometimes lateral pale spot appears on fifth and sixth segments, median of meso- and meta-thorax whitish to yellow. Third instar: Same as previous except that yellow spots on fifth and sixth segments and on median of thoracic segments are always pronounced and anterior margin of pronotum is also pale, median of abdominal segments whitish, giving effect of light median stripe; median and anterior portion of head brownish, while lateral and posterior portion is deep black; legs, especially front pair unusually long. Fourth instar: Same as preceding except that the spots are more yellow and lateral margins of all thoracic segments are pale whitish or yellowish; legs still longer than those of the other species studied; general color dark bluish. This larva strongly resembles the larva of *Olla abdominalis.*

Pupa: Fig. 29, Plate XXXIII.

Ground color pale maize yellow, darker in spots, especially in the depressions between the abdominal segments, a broad band along anterior and lateral margins and a round spot within lateral margin on each side of pronotum. Wing pads dark maize to honey yellow or sometimes quite brownish with posterior margins always brown; black markings as follows: Pronotum with a pair of black spots on anterior and another on posterior margin, also an anterio-lateral pair less pronounced, a pair of median spots on meso- and meta-thorax and on abdominal segments two to six inclusive, third segment with three pairs of spots; legs brownish honey yellow. Length 5 mm.

Life cycle records were made as follows:

Egg stage (7 records) 3-5 days, mostly 4 days.
Larva stage (7 records) 9-16 days, mostly 11 days.
Pupa stage (7 records) 3-5 days, mostly 4 or 5 days.
Egg to adult, 15 to 20 days.

This species has been observed by Mr. Bragg feeding on *Mac. solidaginis*, and in the breeding cages it did well on *Aphis heraclei* Koch., *Rhop. pastinaceae, Mac. gaurae, Mel. smithiae, Aphis setariae, Aphis oxybaphi,* and *Aphis helianthi.*

Some larvae of *Scymnus* species, determined by Major Casey as probably a new species somewhere in the vicinity of *cockerelli* Casey and *consobrinus* Lec., were reared but no life history notes were taken.

Adult: Fig. 31,Plate XXXIII.

Head black, yellowish red between the eyes; pronotum black with lateral thirds yellowish red; elytra black; legs brownish red; entire beetle covered with hairs; length 2.5 mm.; width 1.7 mm.

Egg:

Same color and shape as foregoing species but much smaller.

Larva: Fig. 32, Plate XXXIII.

Pale brownish throughout, but covered with six large tufts of waxy secretion on each segment so as to render the larva quite conspicuous.

In the pupa the larval skin is not pushed down as tightly as in the other *Coccinellids* studied, so that it gives the pupa a white cottony appearance and doubtless affords it considerable protection.

This species has often been found doing valuable service in keeping *A. setariae* in check on the plum. Professor Gillette has often found it abundant with *Schiz. lanigera* on the apple.

GENERAL SUMMARY.

In general appearance and color pattern these species of ladybeetles resembled each other most in the larval and pupal stages. *Coccinella 5-notata*, *9-notata*, and *monticola* resemble each other so much as to form one group. They of course had some characteristic differences but they often intergraded and merged together so as to be indistinguishable until they matured.

H. convergens, together with *H. parenthesis* and *H. sinuata* seemed pretty distinct in these stages but an occasional individual was found which seemed to show no distinguishing character. The *Adalia* beetles, *O. abdominalis*, and *C. sanguinea* seemed to form another group in color pattern of the larva and pupa. The forms of the *Adalia* seemed to be exactly identical in these early stages. *Scymnus*, of course, with its covering of waxy secretion, was entirely different.

In life cycle periods from egg to adult, all the species thus studied, *H. convergens*, *C. 5-notata*, *9-notata*, *monticola* and the genus *Adalia* seemed practically alike. From egg to adult in *H. convergens* took, as a rule, 21 days; in *C. 5-notata*, 20 days; in *C. monticola*, 23 days; in *9-notata*, 20-23 days; *Adalia*, 21-23 days. The age to which the adults lived seemed practically the same, two to three and perhaps four months for the summer generations. In *C. monticola*, however, it seemed that the first generation commonly hibernate so that these beetles would live to a greater age than even the hibernating beetles of the other species in which only the beetles emerging

later in the season hibernated. There did not seem to be any certain fixed generation to hibernate in any of the species but there was no evidence of any females that had laid eggs before winter hibernating and laying again the next spring, and none ever hibernated in other than the adult state.

Of all the species studied, *C. monticola* was the only one where there was any difficulty in breeding males in captivity; in all other species about half of the beetles reared were males, but here there was no evidence of any, and only females captured already fertilized, laid eggs which would hatch. Many of these captured laid infertile eggs or none at all, and none reared in captivity ever laid a fertile egg and most did not lay at all. For three years, no undoubted instance of the finding of a male occurred either biologically by myself, or by Mr. Bragg, who used dissection on captured specimens and had no difficulty finding males in any of the other species. Finally, however, two batches of eggs were reared with special care, one lot producing sixteen beetles from eighteen larvae hatched, and the second producing twelve beetles from twenty-three larvae hatched. The first lot proved, on dissection, to consist of seven males and nine females. The second lot consisted of nine males and three females. Why none have been observed mated, either in captivity or out of doors, and why Mr. Bragg found so much difficulty in capturing males, still remains unknown.

The egg laying periods seemed to be approximately the same for all these species where records were taken, both for the length of time for the individual, and for the laying season. A female would often lay before being fertilized but not as well as after. A female of *Adalia* would not seem to be able to lay fertile eggs for more than about three weeks after being isolated from a male. In *C. monticola*, on the other hand, if a female was once fertilized, it sufficed for the season. In *Adalia*, when a female was changed from one male to another, the later male would take precedence over the former one, almost immediately, so that the eggs laid two or three days after and later would develop the characters of the later male in every case.

In the individual egg records, *C. 9-notata* ranked first, the four highest records being from 435 to 1047; *C. 5-notata* next, with 368 to 539; then *H. convergens* with 199 to 312, these numbers representing the four highest records of each species

respectively. Owing to the difficulty in getting these beetles to lay their full number of eggs in captivity, many of the numbers here may fall far short of what the beetles are able to do, and the differences between the species may have been more or less accidental, though *C. 9-notata* seemed very decidedly to be the most prolific.

Considering the feeding capacity of the larvae and adults of these species, there seemed little difference between them. A larva of *H. convergens* was able to eat 100 *C. negundinis* in a single day, and the highest entire record was 576 aphids of different kinds. A larva of *C. 5-notata* could eat 100 *C. negundinis* in a day and the highest entire record was 620 aphids. A larva of *C. monticola* ate 144 to 190 *A. cornifolii in* a single day, and the highest entire record was 962 aphids. An adult of *H. convergens* ate 120 *A. setariae* in a single day, and one of *C. 5-notata*, 200 *A. helianthi.*

Both in the per day, and the entire record of the larva, *C. monticola* leads, and *C. 5-notata* ranks second. These species are on the whole practically alike in feeding habits and what differences there seem to be may be partly accidental as counts were taken on only four larvae of *H. convergens*, only two of *C. 5-notata*, and five of *C. monticola*, and only two counts of *C. monticola* exceeded the other species, the other three being no higher than in the others. The amount eaten per day varied greatly with the larvae according to the weather and the size of the larva, and in the adult it varied with weather and egg laying.

In range of feed *H. convergens*, *C. 5-notata*, *C. monticola* and *C. 9-notata* seemed practically alike and seemed to comprise everything in the way of aphids except aphid eggs, though the smaller species seemed to be preferred in the breeding cage. Out of doors they all seemed to feed on the large species as well as the smaller ones. For these four species of ladybeetles the following plant lice were used as feed: *A. cerasifolii*, *A. gossypii*, *A. oenotherae*, *A. carbocolor*, *A. taraxici*, *A. torticauda*, *A. oxybaphi*, *A. helianthi*, *A. setariae*, *A. medicaginis*, *A. brassicæ*, *H. arundinis*, *Lachnus* sp., *C. negundinis*, *C. populidola*, *C. populifolii*, *M. gauræ*, *M. cynosbati*, *M. pisi*, *Myzus cerasi*, *Macrosiphum ambrosiæ*, *M. rudbeckiæ*, *Prociphilus fraxinifolii*, *Phorodon humuli*, *S. lanigera*, *Melanoxantherium bicolor* and *M. smithiæ.*

There was no evidence of any of these species feeding on vegetable matter, though they often chew and suck about on the leaves when very hungry and one newly emerged *Adalia* beetle seems to have chewed up a portion of a half dried boxelder leaf.

The *Adalia* beetles had to be fed on only the smaller species of plant lice in the breeding cages, though out of doors they were found by Mr. Bragg to be quite abundant with *P. fraxinifolii*. Early in the spring, 1910 and 1911, they were very abundant with *C. negundinis* and together with the Syrphus larvæ they cleaned these lice off the boxelder trees, though they had been very badly infested. The species used successfully in the laboratory were *C. negundinis*, *M. sanborni*, *Myzus persicæ*, *A. setariæ*, *A. helianthi*, *R. pastinacæ*, and *Macrosiphum cynosbati*.

The injurious influences affecting these species were cool damp weather, which *C. monticola* seemed to stand better than the other species, very large lice that would extrude large quantities of glue from their cornicles, a fungous disease resulting from too much dampness in the cage or perhaps from the decaying bodies of half eaten lice, and frequently beetles were destroyed by a hymenopterous parasite known as *Perilitus americanus*. Ants, also, seemed to be hostile, in one instance killing a larva and in another, an adult, this even in the breeding cage where the ants felt strange and were frightened. Much loss was occasioned by cannibalism, eggs, larvæ, pupæ, and even newly emerged adult beetles, while still soft, being eaten by hungry brothers either larvæ or adults.

As to members in nature, the different species seem to rank differently in different years. From casual local observations, in 1907 and 1908, *H. convergens* ranked first, *C. 5-notata* second, *C. monticola* third, *C. 9-notata* fourth, and *O. abdominalis* and *Adalia* quite rare. In 1909, *C. monticola* was first, *Adalia annectans* second, *H. convergens*, *C. 5-notata*, and *C. 9-notata* not very abundant, and *O. abdominalis* only occasional.

EXPLANATIONS OF PLATES.

Plate XXXII.

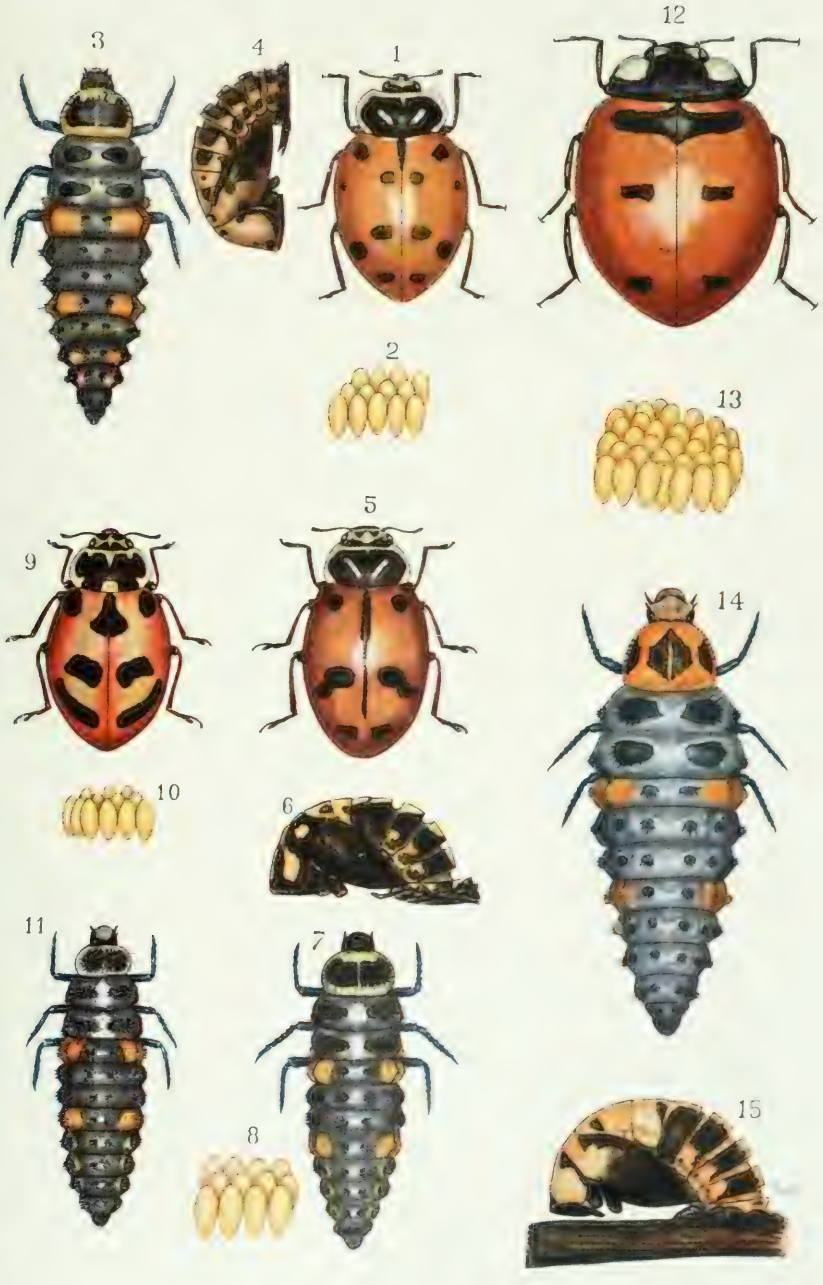
Fig. 1. Adult of *Hippodamia convergens* Guer.
Fig. 2. Eggs of *Hippodamia convergens* Guer.
Fig. 3. Larva of *Hippodamia convergens* Guer.
Fig. 4. Pupa of *Hippodamia convergens* Guer.
Fig. 5. Adult of *Hippodamia sinuata* Muls.
Fig. 6. Pupa of *Hippodamia sinuata* Muls.
Fig. 7. Larva of *Hippodamia sinuata* Muls.
Fig. 8. Eggs of *Hippodamia sinuata* Muls.
Fig. 9. Adult of *Hippodamia parenthesis* Say.
Fig. 10. Eggs of *Hippodamia parenthesis* Say.
Fig. 11. Larva of *Hippodamia parenthesis* Say.
Fig. 12. Adult of *Coccinella 5-notata* Kirby.
Fig. 13. Eggs of *Coccinella 5-notata* Kirby.
Fig. 14. Larva of *Coccinella 5-notata* Kirby.
Fig. 15. Pupa of *Coccinella 5-notata* Kirby.

All drawings magnified five diameters.

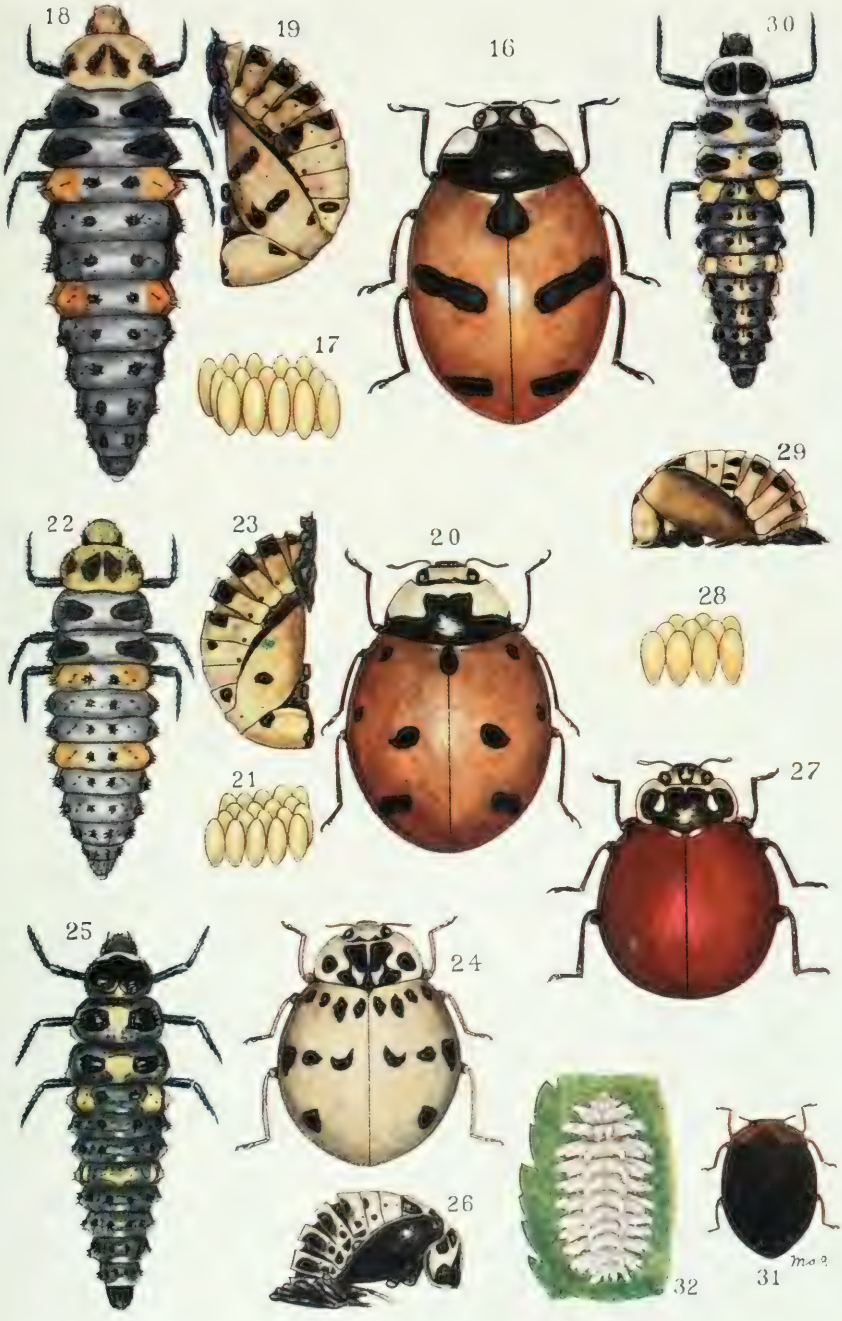
Plate XXXIII

Fig. 16. Adult of *Coccinella monticola* Muls.
Fig. 17. Eggs of *Coccinella monticola* Muls.
Fig. 18. Larva of *Coccinella monticola* Muls.
Fig. 19. Pupa of *Coccinella monticola* Muls.
Fig. 20. Adult of *Coccinella 9-notata* Hbst.
Fig. 21. Eggs of *Coccinella 9-notata* Hbst.
Fig. 22. Larva of *Coccinella 9-notata* Hbst.
Fig. 23. Pupa of *Coccinella 9-notata* Hbst.
Fig. 24. Adult of *Olla abdominalis* Say.
Fig. 25. Larva of *Olla abdominalis* Say.
Fig. 26. Pupa of *Olla abdominalis* Say.
Fig. 27. Adult of *Coccinella (Cycloneda) sanguinea* Linn.
Fig. 28. Eggs of *Coccinella (Cycloneda) sanguinea* Linn.
Fig. 29. Pupa of *Coccinella (Cycloneda) sanguinea* Linn.
Fig. 30. Larva of *Coccinella (Cycloneda) sanguinea* Linn.
Fig. 31. Adult of *Scymnus sp.* magnified 8 diameters.
Fig. 32. Larva of *Scymnus sp.*

All drawings except Fig. 31 are magnified five diameters.



Miriam A. Palmer



Miriam A. Palmer

ON A COLLECTION OF CRANE-FLIES (TIPULIDAE DIPTERA) FROM THE FIJI ISLANDS.

By Charles Paul Alexander, Ithaca, N. Y.*

The following crane-flies were included in material sent to Mr. Harry H. Knight by Dr. James F. Illingworth. The only published reference to the Tipulid fauna of these islands is included in Skuses Diptera of Australia (vol. IV, 2nd series, 1889) and his records are mentioned herewith. I am indebted to Dr. Illingworth and Mr. Knight for this material. The types are in the collection of the author.

Family **Tipulidae.** Subfamily **Limnobinae.** Tribe **Limnobini.**

Dicranomyia saltens Doleschall.

1857 *Limnobia saltens* Doleschall; Nat. Tijd. Ned. Ind., vol. 14, p. 390, pl. 2, fig. 3.

Two, a male and a female, from Nadi on July 27. This seems to be the most easterly station so far made known for this species; it has been recorded from southern India, Java, the Philippine Islands, etc.

Dicranomyia illingworthi, sp. n.

Wings hyaline with sparse brown markings; Sc short ending just beyond the origin of Rs.

Male, length, 4.6 --5 mm.; wing, 5.2 --6.8 mm.

Male: Rostrum and palpi brown. Antennæ dark brown, the flagellar segments globular in shape. Head dark brown.

Thorax rather uniformly dark brown, stripes on the praescutum not well-defined, lobes of the scutum a little darker. Pleurae uniform brown. Halteres pale, stem moderate in length. Legs, coxæ light brown, trochanters brown. Wings hyaline, veins brown; a small rounded brown stigmal spot; pale seams at Sc_2, base of Rs and on the cross-veins and deflections of veins along the cord and outer end of cell 1st M_2. Venation: (See fig. 1.) Sc short, ending just beyond the origin of Rs. Basal deflection of Cu_1 before the fork of M.

Abdominal tergites slightly darkened, the sternites pale, the abdomen rather transparent. Hypopygium with the pleurites short, cylindrical; dorsal appendage chitinized short, slightly curved and acute at apex; ventral appendage large, pale, almost white, with the outline rounded, the inner lobe produced mesad into a cylindrical, feebly chitinized, point that bears two bristles which are directed caudad. (See fig. 7.)

*Contribution from the Entomological Laboratory of Cornell University.

Holotype, ♂, Nadi, Fiji Is., 7-28, 13. Paratypes, 4 ♂s, with the type.

Libnotes strigivena Walker.

Limnobia strigivena Walker, Journ. Linn. Soc. Lond., V, 229, 1861.

This species is recorded by Skuse (Diptera of Australia, Proc. Linn. Soc. N. S. Wales, IV, series 2nd, 787, 1889).

Tribe **Antochini.**

Teucholabis fijiensis, sp. n.

Head dark; thorax with three brown stripes, pleuræ spotted with brown; wings yellowish with brown spots.

Male, length, 7 mm.; wing, 7.4 mm.

Male: Rostrum brown, palpi dark brown. Antennæ with the basal segments of the flagellum rounded, brown. Eyes large, contiguous on the vertex; head dark greyish black.

Pronotal scutum dull yellow, brown medially above; a brown spot on the lateral end. Mesonotal praescutum light yellow with three stripes of which the median one is longest and broadest, extending from the cephalic margin to the transverse suture. The lateral stripes are short and narrow, behind, crossing the transverse suture and ending on the anterior border of the scutal lobes; the lateral margin of the sclerite is suffused with dark brown. Scutum and scutellum brown except the median portion of the former which is pale. Postnotum dark brown. Pleuræ dull yellow, the episternites of the pro- and mesothoraces brown. Halteres pale. Legs, coxæ, fore and middle, brown, hinder pair paler; trochanters pale yellow; femora yellowish brown with a broad brown subapical ring; tibiæ and tarsi brown. Wings yellowish, stigmal spot large, prominent, a small seam on Sc_2; seams at the base of Rs, along the cord and on the outer end of cell 1st M_2. Venation: (See fig. 2.) cross-vein r at the tip of the long R_1 and so placed slightly beyond the middle of R_{2+3}.

Abdominal tergites dark brown, the caudal margin a little more yellowish; the basal two or three sternites yellowish, the others more brown. Hypopygium with the ninth tergite having the caudal margin rounded and very feebly notched medially. Pleuræ short, clothed with sparse long hairs. Dorsal appendage of the pleurite jointed at the base, pale, clothed with numerous long hairs at the base, at the tip slightly bifid underneath. The ventral appendage is a long elongation of the pleura, not jointed at its base, darker and more chitinized; toward the tip it is constricted, the actual apex expanded and bearing a few small hairs. (See fig. 8).

Holotype, ♂, Nadi, Fiji Is., 7-28,'13.

Tribe **Eriopterini.**

Gonomyia (Leiponeura) fijiensis, sp. n.

Thorax brown, lateral margin of the praescutum yellow; wings with the costal margin yellow, the membrane light brown and hyaline diversified, stigma lacking.

Male, length, 4.9 mm. Female, length, 4.8-5.1 mm.; wing, 4.3-4.4 mm.

Male: Rostrum and palpi dark brown. Antennæ light sulphur yellow, the flagellar segments a little paler. The head bright sulphur yellow with three pale brown marks, a median one on the frontal tubercle and others on the sides of the vertex.

Pronotum light yellow. Mesonotal praescutum dark clove-brown the lateral margin between the pseudosuture and the transverse suture yellow, scutum, scutellum amd postnotum dark brown. Pleuræ light yellow, a broad brown lateral stripe, deepest ventrally fading into the yellow of the dorsal pleurites above, extending from the ventral surface of the cervical sclerites through the halteres to the posterior portion of the mesonotal postnotum; the area between this stripe and the praescutum is light yellow suffused with brown near this stripe; sternites dark brown. Halteres light sulphur-yellow. Legs, fore coxæ light sulphur-yellow except the extreme tip which is dark brown; trochanters light brown; remaining coxæ dark brown on the basal half, paler brown apically and on the trochanters; remainder of the legs broken off and confused in the vials with the legs of several other species, but they are probably uniform dark brown. Wings with the costa and the subcosta conspicuously bright sulphur-yellow, remaining veins brown; wing suffused with brown and variegated in places with hyaline, as in cell R_1 which completely lacks a stigma, in cell R, 1st M_2 and elsewhere. Venation as in figure 3.

Abdominal tergites brown, broadly edged with yellow on the caudolateral margins, the brown always continuing to the caudal margin as a narrow median line except in the 8th tergite where the lateral and caudal margin is broadly yellow all around; sternites brown, very narrowly edged with paler on the caudal margin; pleurites broadly and conspicuously yellowish. Hypopygium with the 9th tergite short, broadly concave, yellow. Pleurites rather short, cylindrical, yellow, clothed with long pale hairs, bearing at the tip two appendages; the dorsal appendage is entirely fleshy with two arms, the one directed caudad, the other cephalad, the caudal arm densely clothed with abundant pale hairs, the cephalic arm with a chitinized bristle at the tip and about four smaller bristles on either side, subequal in length and evenly spaced. The ventral appendage is a long simple curved hook, very strongly chitinized. The 9th sternite is very high, convex and bears at its tip two strongly chitinized forked appendages that are directed caudad, the outer fork being cylindrical, acute, the inner fork flattened, twisted and directed entad. The penis-guard viewed from above (fig. 9) is narrow at the base, broadening toward the tip, the lateral edges chitinized and

passing into two sharp chitinized points; viewed from the side (fig. 10) these sharp tips are directed strongly ventrad and viewed from beneath (fig. 12) they are seen to be decussate. Gonapophyses short, directed dorsad at the tip which is blunt and truncated.

Female: Similar to the male but the head of one specimen is entirely dark, the dorsal brown stripe on the pleuræ clearer and narrower not grading insensibly into the yellow of the dorsal pleurites.

Holotype, ♂, Nadi, Fiji Is., 7-28, '13. Allotype, ♀, and paratype, ♀, with the type.

Gonomyia (Gonomyia) varipes, sp. n.

Head yellow with a brown vertical spot; thoracic dorsum brown; legs banded brown and white; wings with the costal margin conspicuously bright yellow.

Female, length, 4.6 mm.; wing, 3.6 mm.

Female: Rostrum and palpi brown. Antennæ with the two basal segments light yellow above, brown on the under surface; the two or three basal flagellar segments are yellowish, the remainder brown. Head light yellow, a narrow transverse brown mark across the front behind the antennæ and a V-shaped brown mark on the vertex with its point directed cephalad.

Pronotum light brown except the scutellum which is very light yellow, a continuation of the dorsal pleural stripe. Mesonotal praescutum very dark clove-brown, uniform; scutum similar except the median portion and the outer caudal angles of the lobes which are paler; scutellum brown, the apical two-thirds pale; mesonotum light brown. Pleuræ and sterna brown except a broad yellow line extending from the wing-root along the dorsal pleurites to the pronotum and a second broad whitish yellow stripe extending from the fore coxæ, above the middle coxæ to underneath the halteres. Halteres uniform light sulphur yellow. Legs,—fore legs, coxæ light yellow at the base, the tip brown; trochanters brown; femora brown; tibiæ, extreme base and apical two-fifths brown, the remainder china-white; metatarsus with the basal half white, remainder of the tarsi brown. One other leg is loose in the vial and belongs to either the middle or hind legs,—here the base of the femur is yellowish passing into brown at the tip; the tibiæ all white except the very narrow base and slightly broader apex which are brown and the metatarsus is white except the tip which is broadly brown; remaining tarsal segments brown. Wings, costa very conspicuously pale sulphur-yellow, remaining veins brown; wing-membrane with a light brown suffusion; cell R_1 paler and containing the oval brown stigma. Venation as shown in figure 4.

Abdominal tergites and sternites dark brown, the pleural region paler.

Holotype, ♀, Nadi, Fiji Is., 7-28, '13.

Erioptera (Erioptera) oceanica, sp. n.

Halteres dark at tip; wings light brown; male hypopygium with the pleura bearing a chitinized knob at tip.

Male, length, 6.3 mm.; wing, 5.4 mm.

Male: Rostrum and palpi brownish yellow. Antennæ rather long, the flagellar segments rather elongate-oval; if bent backward the organ would extend beyond the wing-base; scape brown, the flagellar segments a little paler. Head dark brown and sparsely hairy.

Pronotum brown, clothed with brown hairs. Mesonotal praescutum light brownish yellow without apparent stripes but with a row of hairs on either side of the middle line; scutum, scutellum and postnotum brownish yellow, the latter with a narrow brown median line. Pleuræ light brownish yellow. Halteres rather long, pale, the knob dark. Legs pale yellow with the two apical tarsal segments brown. Wings with a pale brown tinge, the costal region a little more yellowish; veins brown. Venation as in figure 5.

Abdomen long and slender, pale yellow, the seventh sternite brown. Hypopygium with the pleurites very long and slender, densely clothed with long yellow hairs; at the tip of the pleurite are two appendages, the one a dorsal chitinized appendage, slender at the base, swollen at the tip and slightly roughened apically, and a ventral, flattened fleshy lobe that is rather truncate at the tip. (See fig. 13).

Holotype, ♂, Nadi, Eiji Is., 7-28, '13. Paratype, ♂, with the type.

Mongoma fijiensis, sp. n.

Trentepohlii group; wings subhyaline, indistinctly if at all marked; legs without white bands.

Male, length, 6.8 mm.; wing, 5.5-5.6 mm.

Female, length, 8-8.6 mm.; wing, 6.4-6.6 mm.

Male and female: Rostrum and palpi yellowish. Antennæ with the basal segments pale yellow, the flagellar segments brownish. Head dark brown. Neck elongate, brown dorsally, yellow beneath. Mesonotal praescutum light yellow with three elongate brown stripes, the median one broadest in front, narrowed behind and ending at the transverse suture; the lateral stripes are narrower, beginning just back of the pseudosutural foveæ and continue back to the scutum where they suffuse the lobes. Scutum yellow, except the central portions of the lobes which are brown; scutellum and postnotum dark brown except a narrow margin of yellowish. Pleuræ light yellow, the sterna a little suffused with brown. Halteres rather short, pale yellow. Legs, coxæ and trochanters pale yellow, femora, tibiæ and the first tarsal segment brown, the remainder of the legs broken off. Wings with a pale yellow suffusion; veins light brown; stigma rather pale; indications of slightly darker seams along the cord. Venation: (See figure 6). Fusion of 1st A and Cu_2 slight.

Abdominal tergites dark brown medially, this mark in the shape of a long triangle with its point directed cephalad; sternites pale yellow.

Holotype, ♂, Nadi, Fiji Is., 7-28, '13.
Allotype, ♀, and paratype, ♀, with the type.

Mongoma, sp.

A species belonging to the *fragillima* and *australasiae* group in the Macleay collection mentioned by Skuse (Dipt. Aust., vol. 4, series second; Proc. Linn. Soc. N. S. W., Sept. 25, 1889; p. 832, 833.)

Conosia irrorata, Wiedemann.

Sixteen females taken at a lamp at Nadi, Fiji Islands, July 28, 1913. This series shows a great difference in size in the different individuals. It was previously recorded from these islands by Skuse who noted a specimen in the Macleay collection. (l. c., p. 837, 838). The reason that this entire series consisted of females is undoubtedly due to the nocturnal oviposition in this species. Series of photophilous craneflies always show a preponderance of the female sex and many of these are gravid specimens ready to deposit their eggs, the others having laid the clutch earlier in the evening. When males occur at lamps or in trap-lanterns it is probable that copulation takes place in the twilight or early evening.

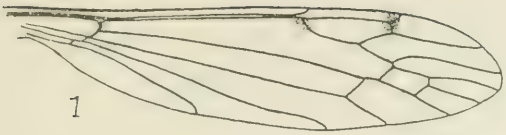
EXPLANATION OF THE PLATES.

Plate XXXIV.

Fig. 1. Wing of *Dicranomia illingworthi,* sp n.
Fig. 2. Wing of *Teucholabis fijiensis,* sp. n.
Fig. 3. Wing of *Gonomyia (Leiponeura) fijiensis,* sp. n.
Fig. 4. Wing of *Gonomyia (Gonomyia) varipes,* sp. n.
Fig. 5. Wing of *Erioptera (Erioptera) oceanica,* sp. n.
Fig. 6. Wing of *Mongoma fijiensis,* sp. n.

Plate XXXV.

Fig. 7. Hypopygium of *Dicranomyia illingworthi;* dorsal aspect of the pleurite.
Fig. 8. Hypopygium of *Teucholabis fijiensis;* dorsal aspect of the pleurite.
Fig. 9. Hypopygium of *Gonomyia (Leiponeura) fijiensis;* dorsal aspect. d—dorsal appendage; v—ventral appendage; p—penis-guard.
Fig. 10. Hypopygium of *Gonomyia (Leiponeura) fijiensis;* lateral aspect. p—penis-guard; pl—pleurite; s—9th sternite.
Fig. 11. Hypopygium of *Gonomyia (Leiponeura) fijiensis;* ventral aspect of the 9th sternite.
Fig. 12. Hypopygium of *Gonomyia (Leiponeura) fijiensis;* ventral aspect of the penis-guard.
Fig. 13. Hypopygium of *Erioptera (Erioptera) oceanica;* pleurite, lateral aspect. d—dorsal appendage; v—ventral appendage.



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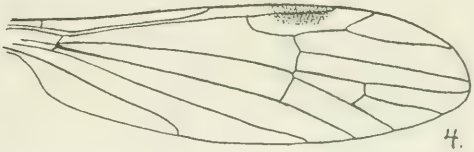

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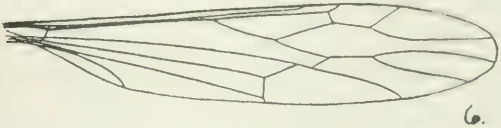

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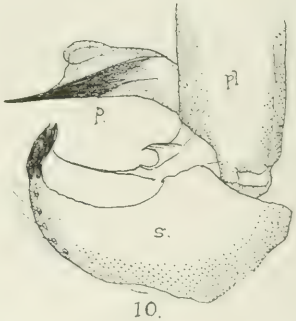

C. P. Alexander.

A NEW SPECIES OF CHEILONEURUS WITH A KEY TO THE DESCRIBED SPECIES FROM THE UNITED STATES.

By A. B. Gahan,
(Assistant, Cereal and Forage Insect Investigations, Bureau of Entomology.)

The new species of Cheiloneurus below described makes the ninth species to be recorded from the United States. In order to more easily distinguish this new form from those already described a key to the species is included.

Superfamily Chalcidoidea.
Family Encyrtidæ.
Subfamily Encyrtinæ.

Key to the Described Species of Cheiloneurus from the United States.

1. Females.....2
   Males.....9
2. Wings hyaline; last two funicle joints pale.....*diaspidinarum* How.
   Forewing fuscus.....3
3. First funicle joint longer than the pedicel.....8
   First funicle joint equal to or shorter than the pedicel.....4
4. Body wholly pale testaceous, except the middle coxæ more or less of the mesosternum, the pedicel, first funicle joint, fifth and sixth funicle joints and the club which are brownish.....*swezeyi* Ashm.
   Thorax not wholly testaceous, with a part at least of the mesonotum metallic or black.....5
5. Antennal club nearly as long as the funicle and much enlarged; pedicel as long as the two succeeding funicle joints.....*dactylopii* How.
   Antennal club much shorter than the funicle and not much enlarged; pedicel not as long as the two following funicle joints.....6
6. Funicle joints all white; scrobes shallow and triangular.....*albicornis* How.
   Funicle joints not white; scrobes deeply impressed and semi-circular.....7
7. Scape flattened and somewhat expanded beneath, brown with a whitish stripe from base to apex; pedicel and first funicle joint nearly equal; antennæ compressed; ocelli less than their own width from the eye margin.....*lineascapus* Gahan.
   Scape slender, pale; pedicel distinctly longer than the first funicle joint; antennæ only slightly compressed; ocelli about their own width from the eye margin.....*cushmani* Crawford
8. Whole funicle as well as the club strongly compressed, all funicle joints except the first distinctly wider than long.....*amplicornis* n. sp.
   First and second funicle joints subcylindrical, following joints and club not as strongly compressed; all funicle joints except the last distinctly longer than wide.....*cupreicollis* Ashm.
9. Scutellum rust red.....*dubius* How.
   Scutellum black.....10
10. Marginal vein very short, scarcely longer than thick.....*dactylopii* How.
    Marginal vein much longer, three or four times as long as thick.....11
11. Forewing with a distinct clouded area below the marginal vein; scape not appreciably expanded beneath.....*cushmani* Crawford
    Forewing without a cloud; scape distinctly though not greatly expanded beneath.....*lineascapus* Gahan.

Cheiloneurus amplicornis new species.

Female—Length 1.5 mm. Head finely closely punctate, from in front much lengthened, the transfacial line about half the length of the facial line, malar space long, scrobes short and very shallow, frons narrow; ocelli in an acute angled triangle, the lateral ocelli scarcely separated from the eye-margins; scape slender, pedicel distinctly shorter than the first funicle joint; all funicle joints strongly compressed, the first a little longer than its apical width, following joints much wider than long; club compressed, not quite so long as the funicle and about equal to the two preceding funicle joints in length; mesoscutum faintly punctuate and closely covered with short pale pubescence; scutellum and axillæ minutely sculptured and opaque, the latter with a tuft of stiff bristles before the apex; propodeum polished; abdomen apparently smooth above. Head reddish testaceous, eyes and antennal flagellum black; scape testaceous; mesocutum black, more or less metallic; scutellum and axillæ pale orange-yellow; tegulæ, pleuræ and most of the abdomen reddish testaceous, propodeum and base of the abdomen above polished metallic green; anterior wings fuscous, a narrow apical border and the basal one-third hyaline; middle and anterior legs concolorous with the pleuræ, posterior legs dark brown, fore tarsi and the apical joint of the median pair brownish as are the posterior tarsi.

Type locality—Dalhart, Texas.

Type—Cat. No. 18801, U. S. National Museum.

Five specimens from the type locality reared by C. N. Ainslie from a coccid, *Eriococcus* sp., infesting *Bouteloua* and recorded in the Bureau of Entomology under Webster No. 5571.

NOTE ON THE NUMBER OF SPIRACLES IN MATURE CHALCID LARVÆ.

By Daniel G. Tower, M. Sc.,
Lafayette, Ind.

During a recent trip to Washington, D. C., while discussing the life history of *Prospaltella perniciosi* Tower a chalcid parasitic on the San Jose Scale, *Aspidiotus perniciosus* Comst., with Mr. J. C. Crawford of the National Museum, he called my attention to a translation of a Russian work published in 1912 entitled, Parasitic and Hyperparasitic Insects, by Iv Chewyreuv, and in particular to a statement made by the author on page 16, which is quoted in full: "In the same paper the author named gave* (25, 35) a much enlarged drawing of *Dibrachys boucheanus* Rtzb. This figure shows not a single spiracle, as if the larva has not got them. While as a matter of fact it does have them, and under the magnification it was drawn, they must be quite evident; nothing is said about spiracles in the description either. The fact is that the arrangement of spiracles in mature chalcid larvæ is very peculiar and as will be shown later, makes it possible to recognize them at once and to distinguish them from the larvæ of allied families. They have nine pairs of spiracles, two of which are on the meso- and metathorax and the rest on the first seven abdominal segments; hence, there are no spiracles on the prothorax and last two abdominal segments. This is the peculiarity Howard did not bring out in his drawing which is therefore incorrect."

The statement made in the above quotation that all mature chalcid larvæ have nine pairs of spiracles does not hold true in the case of *Prospaltella perniciosi*, for the adult larva of this chalcid has only eight pairs of spiracles, two pairs of which are thoracic and six pairs abdominal.

In tracing the tracheal system of this scale parasite through its two larval forms, one finds the tracheal system to consist in the first larval stage of two longitudinal main trunks lying near the surface, one on either side, each bearing ten short, stub-like

*(25, 35) refers in the author's bibliography to Dr. L. O. Howard's paper, "A Study on Insect Parasitism"—U. S. Dept. Agri., Div. Ent. Techn. Ser. No. 5, p. 35, 1897.

branches. During the growth of this form the two longitudinal main trunks join anteriorly and posteriorly, forming an oval. Spiracles are not developed during this stage.

In the second larval stage the tracheal system is at first similar to that of the mature first stage larva, except that it lies deep within the body of the larva. As this larval form grows the first, second and fourth to ninth inclusive short branches of each longitudinal main trunk grow rapidly and terminally at the surface of the body develop spiracles during the last stages of this instar. The third and tenth branches remain short and do not develop spiracles.

The above shows the manner in which the eight pairs of spiracles originate, thus proving that the statement made by Iv Chewyreuv does not hold true.

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